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SURVEY OF THE OHIO RIVER.

U. S. Army Corps of Engineers
LETTER

FROM

THE SECRETARY OF WAR,

IN ANSWER TO

A resolution of the House of January 14, 1871, in relation to the survey and improvement of the Ohio River.

JANUARY 25, 1871.—Referred to the Committee on Commerce and ordered to be printed.

WAR DEPARTMENT,
January 23, 1871.

The Secretary of War has the honor to submit to the House of Representatives, in compliance with the resolution of January 14, 1871, a copy of the report of W. Milnor Roberts on the survey and improvement of the Ohio River.

WM. W. BELKNAP,
Secretary of War.

UNITED STATES ENGINEER'S OFFICE,
Ohio River Improvement, Pittsburg, April 21, 1870.

GENERAL: I have the honor to transmit herewith my general report on the Ohio River, together with complete charts of the river, accompanied by profiles, tables, and an appendix giving information on the subject of the commerce of the principal river cities, rain-fall, &c. The maps on the upper two hundred and seventy-one miles, from Pittsburg to Clipper Mills, were originally prepared by Captain (afterwards Major) Saunders, United States Engineer Corps, and Mr. Charles A. Fuller, civil engineer, and their original maps are in the office of the Chief of Engineers in Washington, District of Columbia. The charts are numbered from 32 to 118 inclusive, beginning at Clipper Mills.

It is proper to mention that the greater portion of the text of this report was prepared some time ago, but the Department having preferred that it should not be submitted till the maps, profiles, &c., were completed, its completion and presentation were in consequence delayed, so that the lapse of time rendered it necessary to rewrite some parts of it.

Additional soundings and numerous observations by the United States assistant civil engineer in charge, Mr. Thomas P. Roberts, and the

Washington
4, 1871

United States consulting pilot, Captain George W. Rowley, commanding the United States engineer steamer *Tidionte*, have enabled us to correct and improve the old as well as our later charts of the river. The regular surveys along the Ohio from the point two hundred and seventy-one miles below Pittsburg to Cairo, covering six hundred and ninety-six miles of river, were conducted under my direction during the years 1867 and 1868, by several United States assistant civil engineers, who performed their arduous labors in an expeditious and satisfactory manner. They had to contend with unusual freshets, which necessarily delayed their operations, and they also encountered severe sickness, especially along the Lower Ohio, which at one time prostrated so many of the parties that the surveys were actually suspended. The names of these gentlemen who thus successfully persevered in the fulfillment of their duties under adverse circumstances deserve to be honorably mentioned. In 1867 the surveys were under the charge of Mr. Alonzo Livermore and Mr. James E. Day, and Mr. Sigismund Low, United States assistant civil engineers.

Mr. Livermore having been called to assist Gen. J. H. Wilson, U. S. A., on the Des Moines Rapids Canal, and the health of Mr. Day not permitting his return to duty, the surveys in 1868 were conducted by Mr. Low and Mr. George Barrett, assistant United States civil engineers. In 1869 a small party was organized for the purpose of making certain local levelings, and taking soundings which could not be made during the previous year, under the charge of Mr. P. H. Morel; and the engineering inspecting party, with the steamer *Tidionte*, made several special trips and additional surveys during 1869, for the purpose of perfecting previous work, particularly in relation to the bars and channels.

Considering the extent of ground covered by the surveys, and the number of islands, bars, &c., I may with propriety congratulate the Department on having secured at moderate cost a correct and valuable chart of the Ohio River, representing, including islands, over two thousand miles of shore-line in the important States of Pennsylvania, Ohio, West Virginia, Indiana, Illinois, and Kentucky.

A large map, on a scale of about two and three-quarter miles to an inch, embracing the whole river and its borders for some distance on both sides of the Ohio, was begun under my direction some time ago; but the duties required of the draughtsmen, in completing the river charts and other necessary drawings, have hitherto prevented its completion. As it will be a valuable addition to the geographical information relating to the Ohio River, I have instructed the assistant engineer to have it finished.

Very respectfully, your obedient servant,

W. MILNOR ROBERTS,

United States Civil Engineer.

Major General A. A. HUMPHREYS,

*Chief of Engineers U. S. A., Office of the Chief
of Engineers, Washington, D. C.*

REPORT BY W. MILNOR ROBERTS, UNITED STATES CIVIL ENGINEER IN CHARGE OHIO RIVER IMPROVEMENT, TO MAJOR GENERAL A. A. HUMPHREYS, CHIEF OF ENGINEERS UNITED STATES ARMY, ON PLANS PROPOSED FOR THE RADICAL IMPROVEMENT OF THE OHIO RIVER; ACCOMPANIED WITH CHARTS AND PROFILE DESCRIPTION OF THE SURVEYS AND WORK CONDUCTED ON THE RIVER DURING 1867-'68-'69, AND APPENDIX.

UNITED STATES ENGINEER'S OFFICE,
Ohio River Improvement, Pittsburg, April 11, 1870.

SIR: In compliance with your instructions dated December 28, 1866, requiring me to present my views upon the various plans proposed for the radical improvement of the Ohio River, whether by locks and dams, reservoirs, dams, and chutes, or other methods, and to collect and eliminate all attainable practical information bearing upon the subject, I have the honor to offer the following report:

Former reports to the Department made some years ago by different topographical engineers, and later reports made by myself, concur in the opinion that the system heretofore adopted to improve the navigation by means of riprap stone wing-dams concentrating and guiding the water into comparatively confined channels, although beneficial and useful, especially to the low-water navigation, does not meet the requirements understood as belonging to the radical improvement of the whole river. The present low-water system, it is true, does not involve a large expenditure of money. It does good and helps the navigation to a certain extent, at a small cost; and it can be effected in a short time, much of it in one or two favorable working seasons. But when finished, although it will be productive of public benefit more than commensurate with the outlay required, it will be no more than an amelioration of the present difficulty. All that has been promised or hoped for under this system, without the aid of artificial reservoirs, has been an increase of twelve to eighteen inches in the depth of the low-water channels, making about two and a half feet where there was only twelve to eighteen inches in the natural river. It is important to effect even this; and the whole amount of money required for this purpose is comparatively insignificant. But the public now using and interested in the navigation of this river is a much greater and more influential and more national body than the public that was concerned in it twenty-five years ago; and such improvements as were then satisfactory are now believed to be inadequate, even for the present river business, and not at all such as ought to be established in view of its future augmentation. Hence the question of its radical improvement is much more important now than it was a quarter of a century ago. The present interests involved are manifold greater; and it is quite obvious that nothing is likely to occur to prevent or seriously retard their future rapid development and extension. So that if there are now six hundred millions of dollars value of river commerce as compared with fifty millions of former times, a few years only in the national life will elapse till there may be a thousand millions in place of the six hundred millions of value of the present time. The permanent improvement of a natural channel of commerce of such vast present and future importance may well command the careful study and attention, not only of the Engineer Department, but of Congress and of the whole country. Plans which years ago may have appeared gigantic, or disproportioned to the extent of the trade then interested, may now be regarded as no more than appropriate to the magnitude of the new commercial necessities of the river.

Yet, forty years ago, in the infancy of the internal improvement system in the great States of Pennsylvania and New York, these single States did not hesitate to invest over \$60,000,000 for State public improvements; and this expenditure has been abundantly repaid in the consequent development, not only of the resources of those States, but of the resources of the Great West. For unquestionably it was largely, indeed principally, owing to the construction of the great canal and railroad thoroughfares through Pennsylvania and New York, (afterwards materially aided by the opening of the Baltimore and Ohio Railroad,) that the West and Northwest became so rapidly settled and developed in such an extraordinary manner. The fact, therefore, that it will cost a large sum of money to make of the Ohio River all that ought to be made of it, as a great national commercial artery, is not and probably will not be generally considered to be of such vital consequence as in early times. The particular mode of improving it, in order to secure the best attainable result, is of more real consequence than the cost of effecting such result. It may be conceded and understood in the outset that, to accomplish the complete, radical improvement of the Ohio River, will require a large expenditure.

Of the several plans proposed, it is believed that only one would secure the proper depth of navigation at all times without aid from artificial supply from reservoirs. The plan of locks and dams, if the works were properly constructed, would, in my opinion, furnish the desired depth at all seasons without any artificial aid from reservoirs. The reasons upon which this opinion is based will appear further on. It is not mentioned here in the way of an argument in favor of that particular plan, but merely as an ascertained fact. The merits and demerits of this plan will be exhibited in this report.

The plan of reservoirs, as the sole means of supplying the Ohio River at all times with an additional flow sufficient to insure in low-water periods a depth of five or even six feet, originated with Charles Ellet, jr., esq., civil engineer, and was very beautifully elaborated by him in various publications, and thirteen years ago its adoption was strongly urged upon the country. His plan contemplated no work upon the river itself; the idea being to accumulate large quantities of water in reservoirs upon the headwaters, or on the main streams above the head of the Ohio, to be drawn off and allowed to flow when needed to maintain the proper depth in the main river. No special surveys were made for the purpose of determining the number and locations of the reservoirs contemplated on this plan. Daily observations had been made through a series of years of the depth of the flow in the channel at Wheeling. From these Mr. Ellet deduced by calculation the theory that enough water falls upon the territory drained above Wheeling, if it were equalized throughout the year, to make a constant depth of over seven feet in that channel. He found by calculation the probable quantity of water required to be stored up in reservoirs sufficient to maintain a depth of six feet through the low-water periods. He also made some personal examinations along the upper portions of the Alleghany River, and obtained considerable information from various sources respecting elevations of different parts of the region in question, all of which enabled him to present his views in very attractive forms, both to the scientific world and to the general public. The practical merits of this plan of reservoirs will be considered in another place in this report.

A third plan for the improvement of the river was proposed by Herman Haupt, esq., civil engineer, in 1855; which consists of a system of longitudinal mounds and cross dams so arranged as to make a

canal on one side of the river about 200 feet wide, or a greater width, and reducing the flow to nearly an average of, say, about six inches per mile between Pittsburg and Louisville. Thus, instead of a series of natural pools and ripples, which now constitute the general regimen of the river, this plan would change it, on a width of two hundred feet or more, to an equable flow due to the general average declivity of the stream.

Mr. Haupt's calculations showed that in extreme low-water stages there is not water enough flowing naturally to maintain the full required depth in such a channel; that some additional supply would be needed from reservoirs; very much less, however, than the quantity necessary to maintain a similar depth in the unobstructed river on Mr. Ellet's plan. The particulars and merits of this plan will be given further on. A fourth plan has been proposed by Alonzo Livermore, esq., civil engineer, the principle of which he secured by patent in 1860. It is a combination of dams and peculiar open chutes through the dams, arranged so as to retard the flow and lessen the velocity of the water from the upper to the lower pool without interfering with the free passage of the boats through the chutes; the *chutes* being substituted for *locks*. This may be regarded as another method or substitute for the open canal and dams which had been proposed by Mr. Haupt as a means of saving water on the reservoir plan. For a certain width of chute, say one hundred feet, the natural low-water flow on Mr. Livermore's plan is deemed sufficient without the aid of artificial reservoirs.

It is proposed to consider each of these four proposed methods of improving the river in the order in which they are already referred to; premising that this order or arrangement has no reference whatever to the respective merits of the different plans, but arises naturally in connection with the periods when the several plans were publicly promulgated. I should further remark here, that although the writer early advocated the idea of the probable future construction of a lock-and-dam system for the Ohio, while engaged as the engineer in constructing the Monongahela steamboat navigation in 1839, he has never been so wedded to that particular mode, or to any one plan, as to hinder him from presenting all plans in an impartial manner to the consideration of those who, with every wish to know their merits, could not be expected to take the time to examine fully for themselves. So that, in entering now upon a reinvestigation of this subject, I am by no means sure which plan, as a whole, may ultimately be deemed most advantageous. It is due to myself, in connection with so grave a question, to state further, that at no time during former examinations into the merits of different plans did the writer feel warranted in recommending without more investigation the adoption of either of the modes proposed.

Within the last ten or twelve years, since there has been any practical movement looking to the immediate radical improvement of the river, essential changes have taken place in the mode of using it, as particularly referred to in my report of December 20, 1866. I allude now especially to the tow-boat system, under which a new class of numerous powerful steamers, running only during coal-boat freshets, has been introduced, in connection with *coal-barges*, which have been substituted for the old fashioned frail coal boxes. This is considered a great improvement upon the former rough, irregular mode of conducting the coal business, although it is still quite irregular as to periods of running, being wholly dependent on freshets, which do not occur at regular intervals; consequently, there are some eight to ten millions of dollars of permanent capital in the shape of steamers, barges, fixtures,

mines, &c., always liable to lie idle, with loaded coal-barges, subject to long delays between floods. And it is not merely this permanent capital that is thus subject to the capricious flow of the stream; large quantities of coal standing loaded in the barges, involving sometimes half a million of floating, unproductive capital, under more or less risk, and the cost of taking care of five millions of dollars' worth of steamers and barges during these worse than idle intervals, entail a heavy tax upon this large and growing interest, already having attained to the shipment of over forty-five millions of bushels annually from Pittsburg alone. These tow-boats, the empty barges, and all considerable steamers, are compelled to withdraw from the river trade when the water falls below three feet in the channel; then a smaller class of vessels may still continue to navigate till the water falls below two feet depth. Very light-draught steamers may run even when there are not more than eighteen inches depth in the channels. But since the completion of numerous railroads in Pennsylvania, Ohio, Virginia, Kentucky, Indiana, and Illinois, so situated as to accommodate to a considerable extent the general travel and much of the lighter trade, it has not been found profitable to run the river when it falls below a two-foot stage, and comparatively little is therefore attempted at such times.

A constant, reliable navigation, which should never be less than five feet deep at extreme low-water periods, which could usually be six feet or more, and which should afford, in times of freshets, a navigation as good as we have now in similar freshets, is the great desideratum. This it is believed can be effected by the liberal expenditure of money. The necessity for some radical improvement, and its expediency, seem to be generally conceded, provided it can be effected in a satisfactory manner, on such a plan as will command general confidence. Objections will be made to the adoption of any plan, some of which objections may be well founded; because it is hardly to be supposed that either plan, in its construction, will not injuriously affect, more or less, some private interest, private views, and present private arrangements. No great scheme designed for general public benefit ever yet escaped objections of some sort.

In the present consideration of the several proposed plans, it is important, therefore, to refer to all known objections, and to take into view all such probable objections as have occurred to those who have carefully reflected upon the subject. The different plans may then be presented under these general heads: Plan; original estimated cost; time of completion; annual cost of keeping up, including attendance; duration of original works; effect on the navigation during construction, &c.; risk, and effect of accidents; general objections: general advantages; together with such views and opinions as may naturally arise during the investigation.

LOCKS AND DAMS.

THE PLAN OF LOCKS AND DAMS.

At the present day, owing to the increase in the size of steamers, especially those navigating the Lower Ohio, and at times the entire river, larger locks than were used or contemplated some years ago have been deemed necessary. The largest lock at present in use on the Monongahela steamboat navigation has a chamber 250 feet by 56 feet, and will pass a boat 240 feet long and nearly 56 feet wide. The new locks at Louisville have chambers 370 by 80 feet; large enough to pass boats

340 by 79 feet. Even these very large dimensions are not sufficient to pass boats that are occasionally built at Pittsburg, destined for the lower rivers. But it would be a waste of money, and very bad engineering, to construct locks of enormous and unwieldy size, merely to say that they were as large as the largest river steamers in the world, when obviously those vessels would never use them, and never have occasion to use them.

Steamers of this immense size will not go down the river excepting when there is such a freshet as would enable them to pass any such dams as should be admitted on the river, even in a "lock-and-dam" system. I mean by this, that in my opinion no dams ought to be constructed in the Ohio River without being provided with chutes so arranged that in a moderate flood vessels could safely pass the chute without being compelled to go through the locks; such chutes, or navigable freshet channels through the dams, being assumed to constitute on the Ohio a necessary part of any proper system of locks and dams. The locks need not be constructed of such extraordinary dimensions. For example, the coal business is done upon a freshet, giving say eight feet or more depth in the natural channel: let the dam be so built that the chute through it shall afford nearly or quite the same depth of channel at such stage of the river. In that case, the locks need to be only of sufficient size to accommodate steamers particularly adapted to the general business of the river. If all the locks of the system were to be erected, at great extra cost, large enough to pass the largest Lower Mississippi steamers, of which only a very few, if any, would ever use them, there would be a very great loss of time, always, to all the numerous smaller steamers using such unwieldy locks, and an unnecessary constant additional cost or tax in loss of time, upon the general river commerce. In this view, a lock considerably smaller than the new locks at Louisville might be practically better under the circumstances; at least above the falls, in the event of the adoption of locks as part of the system.

The general plan for locks and dams, according to these views, would be a medium size of lock, having dams arranged with freshet chutes, such as could be easily navigated in a coal-boat rise.

The fall of the river between Pittsburg and Louisville, on a distance of 598 miles, is 308 feet; and between the foot of the Louisville falls and Cairo, a distance of 365 miles, is 92 feet. The "falls," three miles in length, have a vertical descent of 26 feet; but this may be considered as already covered or provided for by the new, partly-built canal and locks.

Practice of long experience seems to have established about seven or eight feet as a convenient working lift for large locks and dams. I would not recommend the adoption of *greater* lifts for locks on the Ohio River intended for general business, in view of maintaining a safe navigation in moderate freshets over or through the chutes of the dams. Locks of less lift, and consequently dams of the same reduced lift, would afford an equal depth of navigation with a somewhat smaller quantity of lockage water; but the number of locks and dams would be proportionally increased. Thus between Pittsburg and Louisville, when there is a total fall of 308 feet, the number of locks and dams, allowing about eight feet lift to each, would be 38, while with about six feet lift, the number would be 51. The cost of the larger number, with lower lifts, would be considerably more than the cost of the 38 with eight-foot lifts. It is also true that if the lifts were made still higher, and the number of locks and dams thereby diminished, the original cost would

be reduced; but if the height of the dams should be established materially above six to eight feet, the quantity of water required to make the chutes navigable would be much greater, and that particular plan would probably fail. I therefore assume eight feet as the *highest* advisable limit, and six feet as the least advisable lift that ought to be considered in this connection. If six feet be assumed, it would require 51 locks and dams between Pittsburg and Louisville; and for a similar improvement between Louisville and Cairo, 15 locks and dams; in all, 66 locks and dams.

In general, in most streams, dams should be located where the stream in the vicinity is the widest, thus affording the greatest extent of river for the discharge of floods, and lessening the injurious effect of freshets; but on the Ohio, with dams of not over six feet lift, making the comb of the dam only about 13 to 15 feet above the bed of the river, the effect of the dams on the high floods of the Ohio River would be very slight, and practically of no account; and for moderate freshets there would be no particular advantage in lengthening the dam. But while presenting this point, I do not think it necessary to regard it as very important, or as a matter considered either way that would materially affect the estimated cost of the improvement. In a stream like the Ohio, where floods rise to the height of over thirty feet at Pittsburg, over forty feet at Wheeling, and over sixty feet at Cincinnati, and in which thirty feet floods along the river are quite common, an additional rise of a foot or two, at most, that might be caused in moderate freshets by the dams, could not possibly be of much practical consequence, and in the great floods the effect of the dams would be imperceptible.

In making an approximate estimate of the cost, we may then assume, as above, sixty-six locks and dams, averaging about six feet lift each, for the whole 967 miles; and the averaged length of dam on the Upper Ohio at 1,300 feet, and on the Lower Ohio at 2,200 feet, on an average of about 1,474 feet, or allow 1,500 feet each for the sixty-six dams, allowing 300 feet besides at each, to be occupied by the locks and walls. This would be sufficiently near for all present generalizing purposes. Above the falls of the Ohio, locks, one with chamber 370 feet long and 80 feet wide, the other 300 feet long and 60 feet wide at each dam, may be assumed as approximating nearly enough to the dimensions that may hereafter probably be deemed the most advantageous, considering all circumstances. Below Louisville, the present calculations may also be based on locks of the same size as the new locks at Louisville, although I am not now prepared to recommend that size for actual adoption above Louisville. Even if locks and dams should hereafter be selected as the best thing for the Upper Ohio, it would not necessarily follow that they might be the best for the river below Louisville. But the discussion or settlement of such points belongs to a more advanced part of this report, the immediate object in this place being merely to obtain, approximately, the probable cost of some reasonable system of locks and dams for comparison with the cost of other plans.

For convenience of future reference it will probably be advisable to refer to the Upper Ohio separately. The difficulties of the navigation below Louisville are confined to comparatively few places, and the general regimen of the river is sufficiently different to warrant this separation. For present comparison, therefore, the estimates of all the plans may be confined to the 598 miles between Pittsburg and Louisville on the Upper Ohio, where the fall in the river is 308 feet; which, on the plan of locks and dams, would require fifty-one dams of about six feet lift; the dams assumed to be 1,300 feet in length, clear of the lock

walls; the lock walls to average about eight feet above the comb of the dam at the chamber, and ten feet at the head. So that, whenever there should be a freshet flowing eight feet deep over the comb of the dam the pools would be nearly equalized, affording a safe navigation of eight feet over the dams, when the locks would be submerged, (even if there were no chutes in the dams.) A depth of eight feet and upward on the comb of the dam would submerge the lock and render it, for the time, useless, till the flood should recede to less than eight feet depth on the comb; but with the chute arranged either near the lock or at some other convenient place in the dam, a safe navigation through it could be secured with even less than five feet depth flowing over the comb of the dam. This, however, is a secondary or a subsidiary matter, which does not necessarily appertain to the ordinary plan of locks and dams, which could of course be constructed without freshet chutes. All such works will cost much more now than they would have cost ten or more years ago, and it is not probable that lumber, iron, and stone-work, which constitute the leading items, will ever be done as cheaply as formerly. At present the average price of lumber rates about three times as high as it did twenty years ago, and iron-work and stone-work nearly or quite double the old prices. Possibly before the works could be executed prices may fall materially. I present the following as an approximate estimate of the cost of two locks and one dam, with the large dimensions assumed, namely: lock-chambers, one 370 by 80 feet; the other, 300 feet by 60 feet; 7 feet depth of extreme low water; 6 feet lift, and 4 feet guard. Walls at lower gate 8 feet, at upper gates 10 feet above comb of dam. Locks, walls, and abutments of regular-coursed, hammer-dressed stone, laid in cement.

Dam 1,300 feet long, average height to be built, say 15 feet, allowing 2 feet extra over the 13 feet. Base of dam 54 feet, lower slope about four to one, upper slope about three to one. The dam to be composed of timbers averaging not less than 10 by 12 inches square, the cribs filled with rough stone, sheet-piled on the upper toe, and made water-tight on the upper slope with jointed planking, and in part graveled to tighten it and prevent undermining.

Estimated cost of two locks.

38,400 cubic feet of timber in lock foundations, &c., at 20 cents per foot....	\$7,680 00
275,000 feet, board measure, plank, including sheet-piling, at \$40 per M....	11,040 00
22,400 pounds iron bolts, spikes, &c., at 15 cents per pound.....	3,360 00
10,200 cubic yards first-class rubble masonry, at \$11 per cubic yard.....	112,200 00
8,410 cubic yards pit excavation, at \$1 per cubic yard.....	8,410 00
4,400 cubic yards excavation for head walls, &c., at 40 cents per cubic yard.	1,760 00
8 lock gates and fixtures, at \$3,500 each.....	28,000 00
Fender cribs at locks.....	2,000 00
Lock house.....	1,500 00
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	175,950 00
Add contingencies and engineering, 10 per cent.....	17,595 00
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Total cost.....	193,545 00
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Estimated cost of dam and chute.

1,300 feet long; 15 feet high; 54 feet base.

60,000 cubic feet of timber, at 25 cents.....	\$15,000 00
385,200 feet, B. M., plank covering and sheet-piling, at \$40 per M.....	15,400 00
72,200 pounds iron bolts and spikes, at 15 cents per pound.....	10,950 00
4,600 cubic yards of excavation, at \$1 per cubic yard.....	4,600 00
3,200 cubic yards of excavation, at 50 cents per cubic yard.....	1,600 00
21,400 cubic yards stone filling, at \$1 50 per cubic yard.....	32,100 00

11,760 cubic yards of graveling, at 50 cents per cubic yard.....	\$5,880 00
5,400 cubic yards of embankment, at 30 cents per cubic yard.....	1,620 00
1,174 cubic yards of rubble abutment, at \$10 per cubic yard.....	11,740 00
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	98,920 00
Add contingencies, 10 per cent.....	9,892 00
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	108,812 00
Add estimated cost of chute.....	32,000 00
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Total estimated cost.....	140,812 00
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Estimated cost of two locks.....	\$193,545 00
Estimated cost of dam and chute.....	140,812 00
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Total estimated cost of locks, dam, and chute.....	334,357 00
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This sum, \$334,357 multiplied by 51, the number assumed between Pittsburgh and Louisville, gives \$17,052,207 as the total estimated cost of the improvement on this distance of 598 miles, or at the rate of \$28,516 per mile. Applying the estimate to the whole river, inclusive of the "Falls," there would be—

Points which at \$334,357 is.....	\$22,067,562
Add for extra length of dams below the Falls.....	710,100
Add for completing locks and canal at Louisville.....	1,000,000
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Total for 967 miles.....	23,777,662
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Or at the rate of \$24,589 per mile.

There is nothing in the nature of the structures to require more than two working seasons for their completion. It may be considered that at least two years would be required for the opening of the entire navigation, after the final surveys and location of the works. Whether it would be advisable to pursue the plan of completing all within the brief space of two years, is a question by itself, which need not now be discussed: and not at all, unless this particular mode of improving the river should be adopted.

ANNUAL COST OF KEEPING UP AND ATTENDANCE.

Under the head of annual repairs may be included the cost of renewing the wood and iron work exposed to wear and decay, applicable chiefly to the lock-gates. Portions of the wood and iron work of the locks and dams, always under water, and not subject to wear, will of course last much longer than the upper parts of gates exposed alternately to wet and dry.

Dams on the Ohio, if faithfully constructed, need not become actually dry at any time, and ought not to be considered subject to decay, excepting so far as timber and iron constantly under water may be liable thereto. They will last longer than dams on many other streams which have a much smaller minimum flow of water, thereby causing them to be occasionally dry.

I think it will be safe to allow an average of ten years as the life of the wood-work and iron-work of the lock-gates, which are specially subject to wear and to the action of the weather. Lock-gates constructed wholly of iron may be substituted for the wood-and-iron gates, but they would cost much more. They might be composed of thin double plates made hollow and strengthened with interior braces and stays, and built air-tight, so as to lighten them by their buoyancy when

in the water; but the present calculations are based upon ordinary wood-and-iron gates. At the dams, ordinarily, no work of consequence would be required for many years, unless in cases of extraordinary injury from floods, which is of course possible, and which it is proper to consider in the estimates of repairs, extending the estimate through a period of twenty years.

Estimate of repairs and attendance.

One dam and double locks for twenty years:	
Two renewals of eight gates, at \$7,000 per gate.....	\$56,000
Renewal of parts of dam equal to half of original cost, and covering superintendence and extraordinary repairs.....	70,000
Cost of two lock-tenders, at \$2,000 per year.....	40,000
Cost of two assistants, at \$1,000 per year.....	20,000
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	186,000
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Divided by 20, gives per annum.....	\$9,300
Which sum of \$9,300 multiplied by 51, the number of dams between Pittsburg and Louisville, gives annually on these 598 miles.....	474,300
And on 66 dams between Pittsburg and Cairo, gives annually on 957 miles.....	613,800

The above amount of approximate estimated cost is deemed ample to cover all probable contingencies. Supposing it should cost three-fourths of a million of dollars per annum to keep up a perfect navigation, that amount would be saved several times over, as already indicated, even on the business that could be relied upon as soon as the works could be completed. How cheerfully ought that to be paid by those having the benefit of such an improved navigation!

DURATION OF THE WORKS.

In regard to the duration of the works, the foregoing estimated annual cost, judiciously applied, would, it is assumed, maintain them always in order, so that they might be regarded as permanent.

EFFECT DURING THE PROGRESS OF CONSTRUCTION.

In regard to the effect on the present ordinary river navigation during the construction of such works, experience elsewhere has shown about what it will be under proper arrangements. The locks can be built without any interference with the navigation during their erection. The dams will interfere with it for a short time, but with proper management, and by timing the completion of the locks so as to have them entirely ready for use before the middle opening left in the dam for the ordinary navigation is closed, very little delay need occur between the stopping of this temporary sluice-way and the opening of navigation through the lock. And in case navigable freshet chutes should be constructed in the dams, the actual delay might be somewhat less. In any case the final closing of a dam ought to be so managed as not to stop the passage of boats of light draught more than forty-eight hours. They should of course be closed when the river is in a comparatively low stage, and at such periods very few boats now navigate the river. It is obvious, therefore, that ordinarily the delay to be necessarily caused by the completion of a lock and dam, under skillful management, ought not to be a serious matter. At the same time, under careless or ignorant management the delay might be considerable. It is hardly presunable that the construction and care of works of such importance would be intrusted to incompetent or inexperienced hands. On the

whole, it is only reasonable to assume that no serious objection to the plan of locks and dams, as compared with other plans, can be maintained on the score of interference with the navigation during their construction.

RISK AND EFFECT OF ACCIDENTS.

The risk of accidents and the effect of accidents are both worthy of serious consideration. Dams, although they may be well planned and faithfully constructed, are of course subject to injury. Those which may be founded on rock bottoms will be almost free from the risk of damage; but of those which must be founded on gravel, or gravel and sand bottoms, the majority will be more or less liable to settle from undermining that may be caused by the digging out of the bed of the stream and dropping out of the stone filling. This, while it will create extra expense of repairs, need not necessarily interfere with the navigation, especially in dams arranged with navigable chutes. An accident to a dam, if any occurred, would naturally take place in the time of a freshet, at which time the sinking of the dam could not injuriously affect the navigation, either over the dam or through the lock. After the subsidence of the flood, in the low-water period, in case the dam should settle materially, it might for a time draw down that particular pool so as to leave an insufficient depth at the outlet lock on the upper end of the pool; but the remedy in such a case is usually neither difficult nor very expensive. Unless the injury should be much more serious than may reasonably be apprehended, and to which faithfully constructed works would not probably be liable, the navigation would be maintained, either through the chute or through the lock. In case the dam, or a considerable portion, should be completely carried away—a circumstance though possible, yet highly improbable—the river for the time might be even then better for navigation than in its natural state, before the introduction of the system, because the back-water from the next dam below would raise the water somewhat above its original low-water elevation at the injured dam. If two adjoining dams, however, should meet with the same sort of mishap, then the water below the upper of the two would stand at its old natural stage; there would be no navigation through the lock, and only such as the chute would afford through the dam above.

It cannot be said that such accidents are impossible; but the experience of over a quarter of a century on the Monongahela steamboat navigation shows that the possibilities are against their occurrence. At some dams the water may cut out the bed of the river immediately below to a greater extent than at others. In similar cases, where deep holes have been thus excavated, it has been found that the insertion of cribs filled with stone serves to prevent all further danger from such cause. In estimating the cost of repairs and renewals, it is of course proper to make an allowance for contingencies of this nature, but it is not apprehended that a navigation thoroughly constructed on the system of locks and dams would be seriously interfered with from failure of the dams.

The locks, when properly planned and substantially erected, are not liable to material injury. The only parts exposed to actual damage from high floods which would submerge the locks are the gates. Experience on the Monongahela and other steamboat navigations, in Kentucky, &c., has demonstrated that no very material obstruction to the navigation has ever arisen from this cause. Lock-gates thus exposed have very rarely been materially injured by floods. Sometimes sediment, logs, &c.,

settle in the locks or above the upper gates during the submerging floods, which afterwards cause some temporary delay, but for the most part these logs, &c., pass over the dams without affecting the locks. Still it is an objection that there should be any such liability to detention. Through active measures on the part of superintendents the locks could be put in working trim generally by the time the flood had so far subsided that steamers could no longer navigate over the dam or through the chute.

The lock-gates are also liable to injury through the carelessness of steamboatmen or other boatmen running their craft violently against them. In thirty years on the Monongahela navigation there have been but two occurrences of this kind of accidents. Still such accidents may happen.

The best remedy known to me in case of accidents of this nature is to have several finished lock-gates always on hand at a few convenient points along the river, which could be immediately sent to the spot and substituted for the injured gates. All the locks having the same size and lift at each dam, the gates on hand would fit at any of them. This is also an argument for building them all of similar size at each dam on the Upper Ohio, or at least on any considerable stretch of continuous navigation. An accident of the worst kind, such as happened once on the Monongahela navigation, ought not to cause a delay greater than that one, which was four days; but, with navigable freshet chutes, such delay could only occur during periods of low water, as at other stages the steamers, &c., could pass through the chutes or over the dams.

After all, however, the objection must stand that dams and the lock-gates are liable to accidents from the effect of floods and from injury that may be caused by careless steamboating; but, with double locks, the risk of a serious stoppage of the navigation is greatly reduced, it being improbable that both locks would be disabled by one accident, or both at the same time.

In connection with a navigation involving locks it may be proper to refer to a plan with single locks, with a more elaborate and more costly chute in the dam, which would afford a safe chute navigation for about eight or nine months of each year. It is possible that dams can be so arranged with chutes with gates which can be conveniently managed on a channel width of 300 feet or more; which gates should be submerged and entirely out of the way of boats, ice, logs, &c., until required to be raised on account of low water, when there would be only a lock navigation, and which could be readily and quickly let down in case of freshets. In case of the adoption of such a system of navigation it might possibly prove to be advantageous to reduce the fall at each dam to about six feet. This would increase the number of dams between Pittsburg and Louisville (598 miles) to 51, as already shown; and between Louisville Falls and Cairo (366 miles) to 15, making 66 in all.

The first cost of an improvement of this character would not be greater than the estimate already submitted for the double locks with dams of six feet lift. The cost of keeping it up might be somewhat increased. It is not deemed necessary in this place to pursue this further in detail, as it can only be regarded as a modification of the plan of a lock and dam navigation, which of course would be of no practical account if locks should not form part of the system finally adopted. It may perhaps be referred to more particularly in the sequel.

SUPPLY OF WATER ON THE LOCK-AND-DAM PLAN.

Experience on the Monongahela steamboat navigation having demonstrated that occasionally in seasons of excessive drought the water supply on that improvement has been inadequate, it has been assumed by some intelligent gentlemen that the supply might also at times fall short on the Ohio, if it were made into a slack-water navigation.

In 1838, a season of remarkably low water, the Monongahela at one time furnished only 4,500 cubic feet per minute, and the Alleghany at the same period 80,000 cubic feet per minute, or eighteen times more than the flow of the Monongahela at that time; making, at the head of the Ohio, 121,680,000 cubic feet per day. Mr. Ellet's calculations of the low-water flow, with only one foot depth in the channel at Wheeling, was 102,000,000 cubic feet per day. This, it may be assumed, is the minimum flow of an occasional year. In general, there is no period of the year when the flow is not more. But even taking one-fourth from this minimum of 84,500 cubic feet per minute, and allowing that there may possibly be periods of extreme drought when the flow of the Ohio River at Pittsburg should be no more than 63,375 cubic feet per minute, or 91,260,000 cubic feet per day, it would still be ample for the slack-water navigation. Assuming, for a safe calculation, double locks of large size, both with chambers 370 feet by 80 feet, and six feet lift of lock, the quantity required for a single lockage is 177,600 cubic feet. Allowing one lockage every ten minutes during the whole of 24 hours, or 144 lockages per day, the quantity consumed in lockages would be 25,571,400 cubic feet, which, deducted from 91,260,000, leaves a surplus of 65,688,600 cubic feet. This surplus is much more than enough to cover the leakage at the dam and locks, and the evaporation of the pool. And it may be safely assumed that the first pool, at Pittsburg, being thus amply supplied, the additional evaporation on the pools below will be more than kept up by the flow of the numerous tributaries discharging into the river; and consequently that there could be no scarcity at any time for navigation purposes on any portion of the improvement. It must be a very imperfectly constructed dam that should leak even as much as the lockage water above assumed, that is, 1,065,600 cubic feet per hour, or about 8,000,000 gallons per hour. Yet if it leaked that quantity there would still be a surplus of 40,111,200 cubic feet per day. Now the lower dam on the Monongahela improvement is 1,100 feet long, and in low water it has nine feet lift, and yet in *ordinary* low water there is a sufficient supply for navigation purposes. It is fair to assume that the leakage on the Ohio River at one of the dams would be no more than at the Monongahela dam; for, though the average length of dam may be one-fifth or one-sixth greater, the lift being but six feet instead of nine feet, owing to reduced pressure, will more than compensate, in reduced leakage, for the additional length. If, therefore, a navigation in *ordinary* low water can be maintained at all on the Monongahela with a low-water flow of *certainly not more than one-eighth* of the low-water flow of the Ohio, it can scarcely be doubted that slack-water navigation on the Ohio will have an abundant supply of water always.

While it is proper thus rigidly to investigate the extreme case of the period of greatest drought, such as occurs only at intervals of a number of years, it would not be reasonable to assume it as the regular annual low-water stage, for during *six consecutive years*, from 1843 to 1848, inclusive, there was but one month of the year, August, 1843, when the average flow on the Wheeling bar was (a trifle) less than two

feet depth; and but two other months, August, 1845, and September, 1848, when the average flow was less than three feet. With two feet on the bar, the average flow was calculated to be 228,000,000 cubic feet per day, and with three feet on the bar, 400,000,000 cubic feet per day. During the memorable drought of 1838, there was a period of 120 consecutive days when the depth of the bar at Wheeling was less than five feet. The actual average daily discharge during these 120 days was about 220,000,000 cubic feet; so that, notwithstanding there may be a few days, or even a few weeks—occurring, however, at intervals of several years—when, owing to extreme drought, the flow in the upper part of the Ohio may fall as low as 80,000 cubic feet per minute, such a circumstance is very rare. It is doubtful whether there have ever been 30 consecutive days when the flow in the Ohio above Wheeling would have averaged as little as 80,000 cubic feet per minute. Yet even this minimum quantity gives 115,200,000 cubic feet per day, and it is therefore no more than reasonable to consider, in connection with a slack-water navigation, the usual natural low-water supply as equivalent, in round numbers, to 100,000,000 cubic feet per day at the head of the Ohio.

In the preceding calculations of the number of lockages it will be observed that a lock is allowed to be filled and emptied every two minutes throughout the twenty-four hours, and this during the extreme *low-water period*. Admitting as possible that an improved navigation may so equalize the business of the year as to have as many vessels passing during the low-water period as at any other seasons of the year, the amount of trade to be accommodated by the passage of 144 lockages will be truly enormous. Allowing but 500 tons to pass at each lockage, it would give 72,000 tons per day; and allowing only 300 days of navigation per annum, it would be 21,600,000 tons. This vast tonnage is probably more than five times as much as has ever yet passed any point in a year on the Ohio River. Even with the most perfect navigation possible, a great many years must elapse before a trade so immense could accumulate. This fact is referred to pointedly in this connection, in order to show clearly that very liberal allowance has been made for the probable consumption of water, and even with such allowance the supply from the natural flow in the driest season appears to be abundant; for, if the very lowest assumed minimum quantity in any one day of extreme low water, namely, 63,375 cubic feet per minute, be taken as the only supply all the year round, it will be found to be far more than sufficient for slack-water navigation, even with this enormous trade. It should be considered, also, that with a business of such magnitude as to demand a lockage every ten minutes, or 144 lockages per day, the lockages alone would make a respectable stream of water sufficient to maintain the pools ever fresh. This calculated quantity of lockage water per day, 25,574,400 cubic feet, thus locked through, would make a constant flow one hundred feet wide, one foot deep, running at the rate of two miles an hour; while the quantity remaining to cover leakage and evaporation would be more than double of this flow. The remaining quantity, 65,685,600 cubic feet per day, or 2,653,564 cubic feet per hour, is equivalent to a flow 125 feet wide, 2 feet deep, running 2 miles an hour. So far, therefore, as such an important matter as the supply of water for a permanent lock and dam navigation can be ascertained in advance, the conclusion is that there will be water enough at all times, always an ample and generally a superabundant supply. Additional details concerning the flow of the Ohio in its various stages will appear in considering the reservoir.

OBJECTIONS ON ACCOUNT OF ASSUMED INCREASE HEIGHT OF FLOODS.

The first and natural impression of persons who have not had experience in the construction and effect of dams in large streams is, that after their erection the floods will be materially augmented in height in consequence of the dams. Yet abundant experience has demonstrated the contrary. The Monongahela River presents the greatest resemblance, in times of floods, to the Ohio, especially to the Middle Ohio, below Parkersburg, where the fall per mile is nearly the same, namely, about six inches per mile. The dams on the Monongahela were built about fifteen feet high, above the old natural bed of the stream, and so that when finished the vertical fall was about eight to nine feet from pool to pool. Dam No. 1, situated a short distance above the head of the Ohio, at Pittsburg, is 1,100 feet long; about one-fifth or one-sixth less than the assumed average of those required on the entire Ohio. All of the four dams below Brownsville are built on gravel foundations, and consequently are as much exposed to damage from floods as any of the dams on the Upper Ohio would be, as they would all have either rock or gravel foundations. The lower dams, the two longest on the Monongahela River, were built thirty years ago, so that ample time has elapsed to test, in a practical manner, most of the questions appertaining to structures of this sort. We have in this case thirty years of actual experience, which confirms, to the fullest extent, the views expressed in official reports by the writer prior to the erection of those dams, as to the apprehended additional rise of floods.

Sylvanus Lothrop, esq., who was afterward the chief engineer of the Monongahela slack-water navigation for some years, stated in his annual report, in 1846, as follows:

The principle which has heretofore generally been admitted is now ascertained by actual experience and observation to be correct, that whenever the waters of the Monongahela swell to an elevation of eight feet upon the combs of the dams, they then cease to back the water, and the flood is no higher in consequence of their erection. The fall being then distributed along the pools, and the surface nearly equalized, both above and below, they can be passed in either direction by steamboats of the largest class employed in the trade, without hazard or delay.

From my own personal observations during the past three or four years on the same navigation, I am enabled to vouch for the truth of the foregoing statement in every particular, and it conforms precisely to my experience on many other rivers upon which I have constructed dams and studied their effects.

Neither observation nor complaint has shown that the great floods on the Monongahela are any greater now than they were before the construction of the dams. Any one along the river can now observe, as it occurs every year, that when the floods rise so as to make a depth of about eight feet on the comb of the dam, the flow in the stream is nearly equalized; the water of course passing more swiftly at the dam, where it is shallowest. With ten feet depth on the dams the river flows along, both above and below, much the same as it would without them. Hence it is reasonable to conclude, from experience, as fair calculation will also show, that in the Ohio River, where floods of thirty, forty, and even sixty feet occur, the additional height caused by dams only six feet high from pool to pool will be *entirely insignificant*, and practically of no account in their effect upon great freshets.

In erecting dams of thirteen to fifteen feet height above the average bed of the stream, a few instances may occur where small areas of bottom land of little value may be permanently overflowed; but from former experience on the Monongahela, and from personal knowledge

of the Ohio River and its bottom lands, we may be assured that this item will necessarily be a very small one. Any person duly considering the fact that the Ohio River is constantly subject to floods of double, triple, and even quadruple the height of the proposed dams, will see in that circumstance natural and conclusive evidence that there can be no great extent or value of ordinarily available land within fifteen feet vertical of low water. Therefore nothing is hazarded in assuming that the damages that could be caused by the permanent overflow of such pools on the Ohio River would be comparatively trifling.

ICE.

Another objection has been made that the pools will cause the river to be more frequently and longer obstructed by ice, and will render ice-freshets more frequent and more dangerous.

In comparatively low-water stages the Ohio River is already nothing more than a system of natural dams and pools. It is at such low-water periods that the heavy ice is formed. When these pools shall be made from six to thirteen feet deeper, they will of course be *less* liable to freeze, and the ice upon them will therefore be thinner on account of this increased depth of the water. Consequently, in low water and freezing weather the steamers in the natural river are now forced to cease running sooner than they would be in the deeper pools. With the completed slack-water, there would be practically *no period of low water*, and the steamers would never cease to run till very severe freezing should set in. The effect, then, of the slack-water system would be to prolong the time of navigation before closing from freezing; and in some seasons navigation might be maintained, as it has been occasionally on the Monongahela, *nearly all winter*. This, however, depends entirely upon the character of the winter. In ten years' experience on the Monongahela slack-water, from 1845 to 1854, the greatest number of days that navigation was stopped by ice was thirty-three, and in 1868-'69 the navigation continued all winter without cessation; the average number of days per annum for the whole period of stoppages by ice being fifteen and a half days. And the Ohio River was obstructed by ice very nearly the same length of time at the same periods. Combining, for comparison, the obstructions of ice and low water during the freezing months, there can be scarcely any doubt that with a slack-water in the Ohio the detention caused by the freezing on the pools would be less than that now annually experienced on the natural river from ice and low water, as a general thing.

In regard to the second branch of this objection, on a careful consideration of the facts, it would seem that ice freshets ought to be *less* frequent with the deeper pools than in the case of the natural river, or at least not more frequent; and they will certainly be less dangerous, for two reasons: on account of the ice being thinner, and therefore weaker, and because, as soon as it commences moving it will be immediately broken to pieces at the dams and go forward in less formidable masses. Mr. Lothrop, for many years chief engineer of the Monongahela slack-water, reports exactly such experience on that improvement. With an experience of thirty years, the damage caused by ice on that river has not, on the whole, been serious.

During the winter of 1866-'67, I took occasion to witness the breaking up of the heaviest ice that had been known on the Monongahela during twenty-eight years; and no very serious injury was discovered, caused by the dams, or to the dams.

This was one of the most remarkable winters for many years; and

the Ohio River navigation was stopped, in consequence of ice, from the 19th of December to the 24th of December, and from December 29 to January 12, making seventeen days. The navigation on the Monongahela was stopped fourteen days.

All of the Ohio River, with the exception of that portion between Pittsburg and Steubenville, (67 miles,) is further south than Pittsburg; and below that point, on account of its latitude, it is not so liable to freeze as the Monongahela River. Theory and experience therefore appear to unite in favor of the general assumption that the obstruction and danger to the navigation and shore interests, from ice, will be lessened rather than increased by the completion of a slack-water navigation on the Ohio; or that, at most, it does not present any material practical objection to slack-water on this river.

Another objection is, that it will injure the *coal business* and *lumber trade* of the river.

COAL TRADE.

Since the above objection was formally advanced about thirteen years ago, the coal business has been almost completely revolutionized, and instead of being carried on in frail boxes floating with the current and destined never to return, it is now chiefly carried on in regular barges, in fleets managed by powerful steamers, built for this special purpose, called tow-boats. These fleets of barges, drawing from six to eight feet water, are not usually started until there is a depth of about eight to ten feet in the channel; and consequently they are obliged to remain at Pittsburg and other points, sometimes for many weeks together, waiting for what is termed a "coal-boat freshet," before they can leave Pittsburg and the other coal-producing points on the Monongahela and upper Ohio.

The system of barges now in use seems well adapted to the present circumstances of the river. The large and apparently unwieldy fleets, consisting of eight, ten, twelve, and sometimes fourteen barges, on the Upper Ohio, presenting a frontage of 125 to 175 feet, and a total length, including the steamer, of 400 to 500 feet, moving only when the river is in flood, can yet be controlled by the powerful steamers, and many, though not all of them, pass safely throughout the entire length of the Ohio, over its nearly one thousand miles of navigation, notwithstanding its numerous obstructions and dangers; and some of these fleets continue their voyages over a thousand miles further, down the Mississippi to New Orleans. Of course these immense flotillas would be wholly unmanageable without the powerful tow-boat steamers, and sometimes, at certain points, they become partially unmanageable even with their aid. This system, it will be observed, is necessarily spasmodic and very irregular, being wholly dependent on natural freshets. If the freshets were regular, and always reliable, and the navigation were entirely freed from its present numerous obstructions and dangers, as safe as well as an extensive and profitable coal business might soon be perfectly adapted to it, and little more would be needed in connection with this peculiar system; but the freshets, it is well known, are very irregular, and by no means always to be relied upon in advance. The year 1865 was, in this respect, remarkably favorable, and 1866 was still more favorable, on account of the number of fine, available coal-boat freshets; and this had the effect of stimulating the coal business of the year to an unusual extent.

The construction of a regular, always reliable steamboat navigation, on any permanent plan, would undoubtedly work an entire change in

the programme of the Ohio River coal business. The same steamers and the same barges could be employed, or possibly lighter and less-powerful steamers might then be used with advantage steadily, all the year round, making regular trips uninterruptedly, each steamer taking fewer boats than now but running at all times, and therefore making many more trips during the year, with perfect regularity and dispatch; and consequently doing the same, or a larger amount of business, with less capital, at less cost, and at less risk. A steamer of moderate size could pass through the large lock with five large barges at one lockage. Such a "tow" would occupy, say, fifteen minutes in passing each lock, with its 50,000 or 60,000 bushels of coal, (1,785 or 2,143 tons.) If but ten such tows passed daily, occupying two and a half hours at the lock, taking the lowest number of bushels (50,000) to each fleet, and allowing only 300 days of navigation, it would give 500,000 bushels daily, (17,850 tons,) and 150,000,000 bushels for the year, (5,357,000 tons.) The passage of even three such fleets per twenty-four hours would amount to 45,000,000 bushels per annum, or about five millions of bushels more than the whole Ohio coal trade from Pittsburg during 1866—the largest up to that date of any year. This is presented in this particular shape merely to exhibit, in a striking light, the change that might probably take place in the manner of conducting this coal business. The fleets would require, on a single trip, more time than now for the descending trip but less time than now for the return trip; and generally returning nearly empty, or comparatively light, the up trip, except in floods, would take a shorter time than the down trip. Parties desiring to send still larger tows, as they do now, with the heavier steamers, to be run only in cases of freshets, would do so, if they chose, by running only at such times as the floods were sufficient to make a safe navigation through the chutes of the dams, which would occur, as now, several times during the year, though at irregular periods, of course, as heretofore. The probability is, however, that with the navigation thus improved, so as to present at *all seasons* a reliable navigation, six feet deep, much of the freshet coal-boating would, from pecuniary consideration, nearly or quite cease. That is to say, not much, if any, coal would be *held over* for freshets, or little in comparison with the entire annual trade. There is now, every year, a heavy expense attending the coal business, which would then be entirely saved, namely, the watching and bailing of arks and barges; waiting days, weeks, and sometimes months, for a coal-boat rise; meanwhile, also, the powerful and costly towing steam fleet being at the same time idle and under unavoidable expense—altogether making a constant investment of much dead capital, in addition to other continued expenses and risks which never cease, no matter how long the intervals between the coal-boat floods.

Between Pittsburg and Louisville, a distance of 598 miles, with the assumed number of locks 51, the probable time required to tow a loaded five-barge fleet down and an empty fleet back would be as follows:

<i>Descending.</i>		Hours.
Time at 51 locks, 15 minutes each.....		12½
Running time with loaded barges 598 miles. at 5 miles an hour.....		119½
Equal 5 days and 12½ hours.....		132½
<i>Ascending.</i>		
Time at 51 locks, 15 minutes each.....		12½
Running with empty barges 598 miles, at 6 miles an hour.....		99½
Equal to 4 days 16½ hours.....		112½

Total time of round trip, 10 days $4\frac{3}{4}$ hours, or, say, 11 days per trip. Then 11 divided into 300 days, the assumed annual period of certain navigation, would give 27 trips for the year; which, at 50,000 bushels per trip, would make 135,000 bushels (or 48,214 tons) per year for each tow-boat; so that, to accommodate the business done during the past year, 1869, namely, 45,000,000 bushels, would require, say, 33 light-towing steamers, each of only power sufficient to conduct 5 barges. This number of steamers is certainly less than half of the number required to do the business of 1866, on the natural river, even with much more powerful, and consequently more expensive, steamers, though it of course included the coal taken below Louisville for the Lower Ohio and Mississippi.

A little error of judgment, one way or the other, in these approximate calculations of the time, and of the capacity of steamers, &c., will not seriously affect the general comparison, or the general showing here designed to be made. My object is to present merely a fair, reliable comparison, and to show the reasonable probability that, upon a navigation thus improved, the coal business may be conducted *with a very great saving to all concerned.*

In this connection it is proper to refer to the fact that, on the present system, the annual losses to coal shippers are in the aggregate very great, a large portion of which, it is believed, would be saved upon the improved navigation and changed system.

It is considered by men of experience in the present coal-shipping system, that there has been an annual actual loss of from 8 to 10 per cent. of all the coal that starts from Pittsburg. Some place it higher. Thus, on 1,600,000 tons, valued at \$4 per ton, the total value would be \$6,400,000, ten per cent. of which would be \$640,000 for the annual loss in that way. Besides, at present the actual cost of transporting coal, say from Pittsburg to Louisville, is about 7 cents per bushel, or, roundly, say \$2 per ton. Now, if a saving of 25 per cent., or 50 cents a ton, can be effected in this item on 2,000,000 tons, (56,000,000 bushels,) the annual saving in the near future would amount to \$1,000,000, making annually \$1,640,000, if all could be saved. And since the quantity from Pittsburg alone in 1866 was over 1,428,000 tons, and in 1869 over 1,600,000 tons, we may with propriety estimate 2,000,000 tons as the probable quantity within a very few years.

In an enlarged view of this question of saving, it is proper to refer to what the Ohio coal trade will probably attain within the next ten, or even twenty years, in the event of an improved, reliable navigation. It may soon be 5,000,000 tons annually, or even much more. And with no more than 5,000,000, the probable estimated yearly saving in cost of transportation alone would be \$2,500,000; and this on a single article of the commerce of the Ohio River. I am, therefore, led to conclude that the establishment of the slack-water navigation, *or any radical improvement of the Ohio River*, would ultimately conduce greatly to the advantage of the coal business, make it more regular, more reliable, and much more free from risks, more profitable to miners and shippers, and cheaper to consumers; and thus materially aid in its further development. It is true, however that a similar or much better would arise from a constantly reliable six-foot navigation, free from the drawbacks of locks and chutes if such can be secured. Nevertheless, slack-water navigation, in the absence or impracticability of such better navigation, seems to offer a very decided improvement over the natural river with its present precarious, irregular, and obstructed navigation, especially in connection with the coal business. There may be other points in connection with slack-water bearing upon the question of the coal trade,

but those above referred to, it is believed, embrace the chief items of interest.

INJURY TO THE LUMBER TRADE.

In regard to the lumber trade floating on the river, in the shape of rafts, &c., it is assumed that chutes at the dams can be so arranged as to permit them to pass with safety on such freshets as the lumbermen usually descend with their rafts. It is believed also, in the event of a complete slack-water navigation below the head of the Ohio, that large quantities of the lumber would be prepared or manufactured at and above that point, and distributed to the lower river in barges; and with the rapidly advancing prices of lumber, it may be found in the future advisable to carry it nearly all in barges to prevent the deterioration in value caused by its floating so long and collecting the sediment, and, of late years, oil in its pores. It is not urged, however, that the descending navigation for rafts will be improved by the dams, but that such provision can be made by means of proper chutes as will do away with any necessity of using the locks for rough lumber, except as already referred to when put into the shape of prepared or manufactured lumber in barges, although locks might be used of choice occasionally by rafts.

ASSUMED FILLING OF POOLS WITH SEDIMENT.

It has been objected that the pools would fill with sediment. It is well known, as already remarked, that the Ohio River in its natural condition is but a series of pools and natural dams; some of the pools being thirty feet deep and many of them fifteen feet or more. There are on the Ohio River 187 pools having more than seven feet depth in extreme low water, covering an aggregate length of 632 miles. The present pools do not fill with sediment. On the contrary, the frequent floods rising to thirty and fifty feet, or higher, maintain them as a rule in their normal condition. Experience on the Monongahela, which is much more muddy in freshets than the Alleghany River, the larger confluent of the Ohio, does not show any such result. Changes may take place in some of the movable bars, but general experience with numerous rivers on which dams have been in use many years, proves that in all cases when they are subject to considerable floods, as in the Ohio, they sweep out the pools, leaving the navigation unobstructed by sediment. My opinion is that this objection has no real foundation; that there are no reliable facts to sustain it.

LIMIT TO FREIGHT BUSINESS.

It has been mentioned as an objection to locks and dams that they would set a *limit* to the amount of freight which can be transported on the river.

It is true that any lock navigation, however capacious, is not illimitable. In this sense a slack-water system, if unaccompanied with chutes, will of course set a limit; but it must be kept in mind that the present precarious, obstructed, and irregular natural river navigation also sets a limit to the freight that can or will be carried; a limit which is quite *absolute occasionally for several months consecutively*. It is true also that when the river is in flood, or in a perfect navigable stage, as it is for some months every year, its capacity at such periods may be considered for the time unlimited.

Yet the irregularity of these floods, in the nature of the case, actually limits the total trade. It must be granted that if there are any practica-

ble means of obtaining a constant flow of six feet, or even at the lowest times five in the natural river, so as to do away entirely with low-water stages, such a navigation will be very far superior to the most perfect slack-water navigation. In that event the capability of the river as an avenue of commerce would indeed be practically without limit.

It is not with such a river of the fancy, or of the possible future, that we have now to deal or compare with the slack-water. On the contrary, we have a river so subject to fluctuation, and to obstructions interfering with the movement of loaded vessels on account of low-water periods, that it now practically limits the actual freighting that can annually be advantageously or profitably done upon it. The intervals when the navigation is good for a profitable class of freight-boats are now so irregular as greatly to cripple and retard the growth of river trade, and thus also to limit it as well as to tax it heavily in consequence of this irregularity. Admitting that the present precarious navigation might, under this heavy tax arising from stoppages, delays, and irregularities, be naturally more capacious than an ordinary slack-water system, the real practical question at last is, what sort of a limit would the slackwater present? It must be recollected that for one-sixth of the time, or during about two months of the year, there would be a free, unobstructed navigation over the dams, both for ascending and descending vessels, at which times the limitless capacity of the stream would be the same with or without the dams; and that during other considerable periods there would be a safe descending navigation through the chutes, and that then, as now, a large amount of lumber, coal, and other freight might pass without using the locks at all. Let us examine the capacity of the *locks* for freight business, independently of the foregoing additional facilities.

It will be within bounds to allow 15 minutes for the passage of a steamer; and it is not unreasonable to assume that the cargo might amount to 500 tons, (under a regular and always reliable navigation.) This would give 2,000 tons per hour, or 48,000 tons per day, and for the 300 days allowed for navigation 14,400,000 tons per annum. This would be the capacity even of a single-lock system; and with double locks double this business, or equal to 28,800,000 tons per annum. No one would perhaps be justified in asserting that such an immense trade as this is *never* hereafter to be secured on the Ohio River, but this amount is so enormous that it may be considered that the slack-water, keeping in view as we ought the amount of freight that would be passed outside of the locks, sets no limit practically to the freight business on the river, for, if ever the trade should attain to that magnitude and the business should become so crowded as really to demand it, additional locks could be built; at which time, under the circumstances, their cost would obviously be quite insignificant compared with such vast transactions. So that, although there is a limit, it is practically so far off and has reference to so large a trade as not to constitute, in itself, a serious practical objection to the system of locks and dams; although it remains as an abstract objection not applicable to a river with a constant natural channel never less than five feet deep, and generally six feet or more, as hoped for but not existing. Objections: that the pools along the river will render the country unhealthy.

It is somewhat singular that this objection originated with a civil engineer, one who at the very same time was advocating the construction of a vast number of reservoirs and river pools all over the country, which it was proposed to draw down in summer as feeders for the Ohio River; and while contending that such reservoirs, thus used and emp-

tied in the hot season, would not be unhealthy, asserted or claimed that the suggested pools on the Ohio River would be pestilential and create sickness, although they were never to be drawn out, as in the case of the other proposed reservoirs.

My experience on the Lehigh, the Schuylkill, the Susquehanna, the Juniata, the Kiskiminetas, and the Beaver Rivers proves that in every case the river valleys were more healthy after the erection of the dams and slack-water than they were before. Along the Monongahela also the health of the valley has been improved and its population very largely increased in consequence of the advantages of the slack-water.

The quantity of water that would be contained in slack-water pools on the Ohio River would be very great, much greater than now, and the healthfulness of the Ohio Valley would in my opinion be improved rather than injured by the construction of the dams. I cannot, therefore, without doing violence to years of experience and to my own judgment, regard the proposed river pools as in the least objectionable on the score of their fancied insalubrity. This objection cannot, I think, be sustained, either theoretically or practically.

DELAYS AT THE LOCKS.

Another objection is made on account of delays to steamers, &c., at the locks. It is a legitimate objection, which appertains to locks, that all vessels using them must of necessity stop, and be delayed some minutes at each lock. But in the case of a slack water on the Ohio there are compensations which reduce the actual total delay in the trip of a steamer very considerably; and, compared with some stages of the natural river, as for instance in very low water, the round trip could be made quicker in the slack-water, notwithstanding the delay at the locks. On the Monongahela slack-water, between Pittsburg and Brownsville, the distance is 55 miles, with 4 dams and locks. Captain E. Bennett, who has long run steamers upon that improvement, stated some years ago as follows: "The time of running the 55 miles, including the passing of the four locks, varies from 6 hours to $5\frac{1}{4}$ hours, (9 to $10\frac{1}{2}$ miles an hour, including the delays,) by different boats. Generally it takes as long to go down as to go up. We count the time it takes, *including all stoppages for freight and passengers*, 8 hours up and 8 hours down. The average time to pass each lock is from 7 to 10 minutes, but it can be done much quicker if required. A boat has been passed through No. 4, in a good stage of water, in 2 minutes 20 seconds. We can land, put out a passenger, and get under way again in from two to three minutes. Before the completion of the slack-water I do not recollect coming up from Pittsburg to Brownsville in less than *twelve hours*, and frequently from *twenty to twenty-four*. * * * We frequently make the trip when the river is frozen to the thickness of three inches. * * * I think the ice does not form so quick in pools in the first freeze as it did before the dams were built, owing to the greater body of water to be brought to the freezing point. *

* * * I cannot say that the boats have been stopped by low water more than in the summers of 1854 and 1856. In 1854 our boats were laid by 82 days, and a good part of that time there was no navigation for any steamboat of lighter draught, (our boats draw 3 feet light.) Our locks and dams have not caused much detention by, being out of repair. We are occasionally detained for a short time by something getting behind or before the gates, so as to prevent their opening or closing."

There can be no question that the time of navigating has been lessened on the Monongahela by the use of the slack-water.

The average length of pools on the 598 miles between Pittsburg and Louisville, with 51 dams of six feet lift, would be about $11\frac{3}{4}$ miles. The pools would be shorter on the upper end nearest Pittsburg, and longer on the lower part. In a round trip between Pittsburg and Louisville and back, there would be 102 lockages, and allowing 15 minutes lost at each, it would give $25\frac{1}{2}$ hours thus lost at the locks. Allowing one stoppage to land passengers, &c., in each of the 51 pools, both going and returning, or 102 stoppages in all, and three minutes lost time at each, would give 5 hours 6 minutes lost in landings. Allowing for general steamers a running average rate of 12 miles an hour going down, and an average of 11 miles an hour going up, would give $51\frac{1}{4}$ hours down, and 56 hours up; making a total of 138 hours, or 5 days 18 hours, including landings and lockages, on the slack-water, allowing no time at Louisville.

On the natural river, with about five to six feet water in the channels, which is regarded as a fair stage for running, steamers on an average may run down stream about 14 miles an hour, and up stream about 8 miles an hour. This would give an average both ways of 11 miles an hour, or for the 1,196 miles round trip, say 109 hours. Add for 51 landings down, at 5 minutes each, $4\frac{1}{4}$ hours, and 51 landings up, at 3 minutes each, $2\frac{1}{2}$ hours, total $116\frac{3}{4}$ hours, equal to 4 days $20\frac{3}{4}$ hours. Difference $21\frac{3}{4}$ hours in favor of the open river in such a good stage.

The best stage of water for the packets in the natural river is about 15 feet at Pittsburg and 20 feet at Cincinnati. The time from Pittsburg to Cincinnati, down, about 28 to 30 hours; has been done in 27 hours down, and 45 hours up, on this distance of $466\frac{1}{2}$ miles. This gives an average of about 17 miles an hour down and 10 miles an hour up; but when running thus against time the down landings would not be more than two or three, and running up they would stop their engines only long enough to take a wood or coal-flat in tow about three times, *not landing at all*.

The average landings down, in a business trip on the natural river, would now be about 25, and up about 35 between Pittsburg and Cincinnati. The higher the water, the more time lost in rounding to, on the descending trip. The average time out from port to port, round trip, is about $5\frac{1}{2}$ days; about 33 hours lost at Cincinnati, and about 11 hours landing. This would leave 88 hours for running time, on 933 miles round trip, or an average of 10 miles an hour. In ordinary low water, the time consumed in the running round trip would be from 6 to 12 hours longer than in high water. Taking the average at 9 hours longer, it would bring the average running speed, down and up, to 9 and 7 miles an hour, not allowing for any lost time by grounding. These facts were furnished by Captain C. W. Batchelor, an experienced Ohio River steamboat-man. My own opinion is that in moderate stages of water, on a slack-water navigation, the average rate of speed for the same vessels would be about 12 miles an hour down and 11 up, or an average of $11\frac{1}{2}$ miles an hour both ways; on 933 miles this would give 84 hours, or 3 days 12 hours running time for the round trip, exclusive of the delays at the locks, which at 15 minutes per lockage would be 23 hours.

In very low water the regular packets cannot now run. In ordinary seasons they are laid up $3\frac{1}{2}$ months on an average. Very light-draught boats formerly ran all summer, when there were 20 inches of water in the channel. Navigation on the Ohio River may be roundly divided thus: $3\frac{1}{2}$ months below 4 feet; $2\frac{1}{2}$ months above 12 feet; and 6 months, *at*

irregular intervals, between 4 and 12 feet. There will be $3\frac{1}{2}$ months of the year when the slack-water would have greatly the advantage in time, keeping in view *low-water delays*; 6 months when the advantage would be in favor of the natural river; and $2\frac{1}{2}$ months when they would be about equal; that is, when the steamers could run over the dams. But in all these approximate comparisons it is also to be considered that now, with the river in its present natural unimproved state, there are frequently from two to four months of the year when the larger boats, and even medium-size steamers, *cannot run at all*; and also at times extreme low-water periods when practically there is no good navigation even for very small boats, though this last case does not occur every year.

Under such contingent conditions it is obvious that the case does not admit of mathematical demonstration; it belongs eminently to the domain of merely practical approximations. While, therefore, the use of locks and pools would involve loss of time, when compared with the natural river only in its good stages, it would in the aggregate in some years be a saving of time, taking the year round. The delays at the locks ought not to be considered without also taking into account the saving of much more considerable delays now caused during the year by the precarious, uncertain stages of the natural river, induced mainly by low water, though this is not available in a comparison with a perfected river navigation. In case the slack-water plan should in other respects be deemed feasible, advantageous, and advisable for the Ohio River, the question of delays, vexations, and extra cost of steamboating, shipping coal, &c., caused thereby, should receive the most careful consideration. It is a question whether the delays, &c., now unavoidably encountered to a great extent every year, are not in the long run much more annoying and costly to the river men than would be the delay caused by lockage, when taken in connection, as it should be, with regularity, safety, and the perennial nature of the lock-and-dam navigation. It is not, however, my purpose or wish to earnestly press this point; but I desire fairly to present it to the consideration of the Department and to all persons interested in the radical improvement of the river.

In the sequel, after having completed the investigation of other plans, I will be prepared to present them all in comparison with each other.

I will now refer to the reservoir plan.

RESERVOIR PLAN.

The originator of this proposition for the permanent improvement of the Ohio was Charles Ellet, jr., esq., civil engineer, since deceased. It was afterward strenuously advocated by Elwood Morris, esq., civil engineer. The plan itself, of storing up the rain-fall to feed navigable rivers in times of drought, is not new, the same having been discussed in a work written by Mr. Thomas Telford, the distinguished English civil engineer, about the year 1800. Mr. Telford urged the plan for the improvement of the navigation of the river Severn. His plan was "to collect the flood-waters into reservoirs, the principal ones to be formed in the hills of Montgomeryshire, and the inferior ones in such convenient places as might be found in the dingles and along the river. By this means the impetuosity of the floods might be greatly lessened, and a sufficient quantity of water preserved to regulate the navigation in dry seasons, &c. This, it is thought, might even prove the simplest and least expensive mode of regulating navigable rivers, especially such as are immediately on the borders of hilly countries."

Mr. William Jessup, another English engineer of those times, said on one occasion, "Rivers may be rendered nearly uniform throughout the year by reservoirs;" while Mr. Rennie, another distinguished English engineer, remarked, "After what has been said respecting the excess of flood-water in the river Roch, above the ordinary supply, the *idea of correcting the floods of the Severn by reservoirs must appear to be ridiculous.*" The Severn is very far inferior in size, length, extent of drainage, height of floods, &c., to the Ohio, the whole length of the Severn up to Welsh Pool being but 155 miles, while the Ohio up to Pittsburg is 967 miles. The highest floods in the Severn were about sixteen feet, the average height of floods about seven feet; while the highest floods in the Ohio are from forty to sixty feet and the average height of floods is over twenty feet.

My own careful investigations of the subject of controlling the floods of the Ohio by means of artificial reservoirs, which were made in 1857, satisfied my mind conclusively that such control by any human means attainable within the practicable limits of cost is impossible. I will not, therefore, in this report devote any space to the consideration of the reservoir plan *as a means of controlling the floods of the Ohio River.* My present attention will be turned wholly to its consideration as a means of effecting a perennial flow in the natural channel of the river sufficient to make a navigation six feet deep at all ordinary periods of low water, and not less than five feet deep at a period of extreme drought.

The area of country drained above Pittsburg, and which sheds its rainfall into the two confluent, the Alleghany and Monongahela Rivers, which form the Ohio, is about 240 miles long from north to south, and about 80 miles wide from east to west, comprising about 19,200 square miles. The area drained above Wheeling has been considered to be 24,337 square miles. It is sufficiently accurate for all practical purposes to consider 19,000 square miles as the area of gathering-ground for the waters concentrated at Pittsburg.

Observations of the flow of water passing Wheeling have shown that there was one year, 1845, when it represented only 9.83 inches depth from the area above quoted, viz, 24,337 square miles. This was the assumed available total quantity at that point for the year, according to Mr. Ellet's investigations and calculations. We may, however, safely estimate the minimum available average annual rainfall passing Pittsburg at 12 inches on the area of 19,000 square miles, giving a total for the year of 529,689,600,000 cubic feet. So that if the whole available rainfall were stored in reservoirs it would afford a daily flow of 1,423,807,123 cubic feet. According to the calculations, this would have made a constant average depth of nearly seven feet at Wheeling.

The quantity required to keep up six feet depth at the same place was calculated from the flow at Wheeling to be 1,164,000,000 cubic feet per day. Supposing only the same quantity to be sufficient to maintain six feet depth between Pittsburg and Wheeling, and especially between Pittsburg and Beaver, where the fall is about 15 inches per mile, it would prove that usually enough rain falls annually, if it could be equalized, to afford six feet depth constantly at Wheeling, and perhaps nearly six feet at all points below Pittsburg and above Wheeling.

If provision could be made for keeping up a steady natural flow of six feet between Pittsburg and Beaver, where the most rapid descent occurs, it would be ample at all points below; bearing in mind the additional supply from the lower tributaries. To bring the water from the low stage of one foot to a six-foot stage, it was calculated would

require a daily supply, at Wheeling, of 1,062,000,000 cubic feet. (The calculated daily flow of the low-water depth of one foot at the same place was 102,000,000 cubic feet, about one-tenth enough.) Assuming now that 100,000,000 cubic feet per day represents nearly enough the low-water flow of one-foot depth at Pittsburg, and that about 1,200,000,000 cubic feet per day represents the entire quantity required to keep up a six-foot flow between Pittsburg and Wheeling, it would require 1,100,000,000 cubic feet daily to be provided artificially during such low-water periods; and, of course, less in proportion on different stages of the river, up to a six-foot natural flow.

It is important to determine how many days of low water ought to be provided against, although in most years a smaller number might occur. We must anticipate that what has happened in times past may happen again.

In 1838, the river was—

	Days.
At or below a one-foot stage, (some days as low as ten inches).....	32
Between 1 and 1½ feet stage.....	13
Between 1½ and 2 feet stage.....	17
Between 2 and 2½ feet stage.....	37
Between 2½ and 3 feet stage.....	5
Between 3 and 4 feet stage.....	29
Between 4 and 5 feet stage.....	28
Between 5 and 6 feet stage.....	3
Total below 6 feet	164

No two successive seasons are alike. And it may be said that even in a long series of years no two of the seasons are alike in the flow of water in the river. In 1854 the extreme low water was lower on the Upper Ohio even than in 1838; so that on the upper part of the Ohio River the navigation nearly dried up, while on the lower portion of the river there was still some navigation. Local causes operate powerfully on the Ohio River, so that its whole length is not often at precisely the same stage for navigation. Of course, a very heavy flood at the head of the Ohio will cause a flood of some extent to pass over its entire distance of nine hundred and sixty-seven miles to Cairo; but often floods enter into the Ohio from its large tributaries below, without any equivalent rise on the main stream above them. And sometimes when the head waters of the upper Ohio are suffering from drought, the lower portion may still be well supplied from the lower tributaries. Even as high up as Pittsburg, at the head of the Ohio proper, sometimes the Monongahela is in flood when the Alleghany, the other confluent, is not, and *vice versa*.

All this arises naturally from the immense area and different topographical character, climate, &c., of the territory drained by the Ohio and its numerous branches. When it is considered that this area is 214,000 square miles, or 45,000 square miles more than the territory drained by the Mississippi proper above the mouth of the Missouri. (that being only 169,000 square miles,) such effects can be easily understood. The northern heads of the Ohio, in New York State, are in latitude 42° 20', while the mouth is in latitude 37° north, not far above the lower boundaries of Missouri and Kentucky. Its eastern tributary heads are in longitude 78°, and its mouth in longitude 89° 20' west; thus comprising 5° 2' of latitude, and 11° 20' of longitude, western tributary heads. Its whole length, from its sources in Potter County, Pennsylvania, to Cairo, Illinois, is about 1,300 miles. No river in the United States, if we except the Missouri and Lower Mississippi,

drains a region of equal extent. And, according to the able and elaborate report made in 1861 by Captain (now Major General) A. A. Humphreys, and Lieutenant (now Brigadier General) H. L. Abbott, the downfall of rain over the Ohio drainage is greater in actual water supply than that of the Missouri; the Missouri area being therein stated at 518,000 square miles, with an average annual downfall of 20.9 inches, giving an annual river discharge of 3,780,000,000,000 cubic feet. Ratio between downfall and drainage, 0.15. Mean discharge, 0.15. Mean discharge per second, 120,000 cubic feet. While the Ohio, with an area of basin of 214,000 square miles, is stated to have an average annual downfall of 41.5 inches; annual discharge 5,000,000,000,000 cubic feet. Ratio between downfall and drainage, 0.24. Mean discharge per second, 158,000 cubic feet. The discharge from the Ohio being 31.66 per cent. greater than from the Missouri. The area of the basin of the Upper Mississippi, 169,000 square miles. Downfall of rain, 35.2 inches. Annual discharge, 3,300,000,000,000 cubic feet. Ratio between downfall and drainage, 0.24. Mean discharge per second, 105,000 cubic feet.

The discharge from the Ohio, as stated, is, therefore, 50.47 per cent. more than from the Mississippi above the mouth of the Missouri. In the same report, page 93, the features of the main Mississippi (or combined Missouri and Mississippi) are stated as follows: Drainage area, 8,244,000 square miles; downfall of rain, 30.4 inches; annual discharge, including three outlet bayous, 21,300,000,000,000 cubic feet; ratio between downfall and drainage, 0.25; mean discharge per second, 675,000 cubic feet.

The discharge from the Ohio River alone is, therefore, 23.40 per cent. of the total discharge from the entire Mississippi, Missouri, Ohio, and all their tributaries to the Gulf combined. Nearly one-fourth of all the water discharged by the mouths of the Mississippi into the Gulf of Mexico is therefore furnished from the Ohio drainage. The annual depth of rainfall in that part of the basin of the Upper Ohio above Pittsburg is probably less than the depth of the entire Ohio rainfall given in the report quoted for the entire basin. It has been usually assumed above Pittsburg approximately at an average of 36 inches for the upper portion of the Ohio Basin; and the observed flow of the water in the river at Wheeling, embracing the flow from about 5,000 additional square miles, having one year shown but 9.83 inches depth of rainfall passing, it has been considered that about one-third of the average annual downfall flows off by the river, and that 12 inches of the 36 inches of rainfall might safely be assumed as the available supply for navigation from that region.

In the report of General Humphreys the downfall of rain throughout the entire Ohio region area of 214,000 square miles is said to be 41.5 inches, of which 24 per cent. are discharged by the Ohio. This gives 10 inches out of the 41.5 inches as available.

Nothing short of an extensive system of rain gauges at numerous points, with careful records through a number of years, could give more accurate or more reliable data than we now have bearing upon this question respecting the quantity of water annually passing at the head of the Ohio. Nor is strict accuracy at all necessary for the present partly theoretical investigation of the subject of the reservoir plan, since it is clear from the premises, and the data already cited, that enough water flows during the year, if equalized, to secure the desired navigation of about six feet depth all the year round.

Mr. Ellet, the distinguished engineer who projected this plan for the Ohio River, and Mr. Elwood Morris, who advocated it afterwards,

appear to have convinced themselves of the feasibility of thus equalizing it at a very moderate cost.

It may be proper to mention here that I made an informal examination or criticism of their views in an article which was published in the Journal of the Franklin Institute in 1857, my chief object at that time being to call the attention of our public men at Washington to the importance of *investigating* carefully before adopting finally *any* plan then proposed for the radical improvement of the Ohio River, inasmuch as Congress was then very strongly importuned to make an immediate appropriation for the construction of several reservoirs, as a commencement of Mr. Ellet's plan for adding to the natural flow of the stream.

I believed then, as I think was proved, that while this reservoir plan may be demonstrated to be *theoretically* practicable as a means for equalizing to a certain extent the flow in the river, such partial equalization would cost very much more than its projector anticipated; and there are practicable, unavoidable, and insurmountable difficulties, which probably must forever prevent the actual accomplishment of such equalization.

These difficulties are occasioned by the immense body of water which it was proposed thus to control, and by the fact that, even supposing reservoirs in sufficient numbers and capacity to be constructed to hold the entire flow which passed Wheeling from the drainage above it during the year 1845, namely, 555,482,000,000 cubic feet, the projector of the plan showed that in 1847 the quantity was 1,142,258,000,000. The difference is 586,776,000,000, or more than the entire flow of 1845. And even in that year of abundant flow, (1847,) when this immense body of water passed Wheeling, that quantity, enormous as it is, constituted less than one-fifth of the discharge of the Ohio River. The average discharge assigned to the Ohio, in the table referred to, being 5,000,000,000,000 cubic feet, consequently the discharge of an abundant season is considerably more.

It was proved, from an examination of the records of the floods on the upper part of the Ohio, that some of the highest floods occurred when such reservoirs, had they been in existence, must have been full. Such being the case, they could not have aided in restraining those floods. And this would certainly be the case almost every year, if not (to a considerable extent) every year, owing to the utter irregularity of the periods when great floods occur. Let us glance for a moment at this one fact, namely, that if by possibility there could be a gigantic dam, four hundred feet high, at Wheeling, sufficient actually to stop and absolutely to control all the water of the 27,337 square miles of drainage above Wheeling, it could not restrain any portion of the flow from the remaining 189,663 square miles of the Ohio Valley, nearly seven times the area. We should even then have control of only about one-ninth of the area of the Ohio River territory. As a practical engineer I cannot hesitate, therefore, in expressing the opinion, that the scheme of controlling or of equalizing the floods of the Ohio River, by means of artificial reservoirs, is certainly impracticable; and that in any merely human view of the question, it is practically an engineering impossibility, which it would be a waste of time further to investigate, excepting, as now, collaterally.

The question of constructing reservoirs of sufficient capacity to supply the Ohio River in low water, so as to raise the river from a one-foot to a six-foot stage or to a five-foot stage, is entitled to serious consideration. The quantity of water required to be stored for this purpose is very much less than the whole flow of the Upper Ohio in some seasons.

although it is still so large as to be very difficult and expensive to command by artificial means; much more difficult and much more expensive than the projector and advocates of the reservoir plan fancied or estimated. To bring the river from a low-water stage of one foot to a six-foot stage, as we have assumed, would require, as already mentioned, a daily supply of 1,100,000,000 cubic feet. If we assume, also, that continuous low-water periods may occur equivalent to 100 days, it would require 110,000,000,000 cubic feet from artificial reservoirs. Accuracy in regard to this particular point cannot be arrived at; it does not appertain to the nature of the problem; nor is it very important; but it may be said that, with this additional quantity of water at perfect command, the navigation during most seasons might be kept most of the time at or near six feet depth. The quantity to be stored in this case would be, as above, 110,000,000,000 cubic feet. From the records and calculations of Mr. Ellet, as applied to one year, 1841, when for 109 days the water at Wheeling was below three feet, it appears that the flow due to a six-foot stage in the natural river would be—

	Cubic feet.
For 109 days	125, 876, 000, 000
And deducting the natural flow during the same 109 days	17, 147, 000, 000
Artificial supply needed for 109 days	<u>109, 729, 000, 000</u>

There were 109 days in 1841 when the river was at or below five feet, and 207 days when it was below six feet. Approximate calculations made the total probable artificial supply in that case needed at Wheeling to be 143,729,000,000 cubic feet. The advocates for the reservoir plan assumed the quantity to be stored in reservoirs at 150,000,000,000 cubic feet in round numbers, which may be regarded as sufficiently near for all present purposes of comparison, even when made applicable at the head of the Ohio for that portion of the river which has the greatest fall—fifteen inches per mile—between Pittsburg and Beaver. If, upon future critical investigations, in case they should be made, this quantity might hereafter be placed at somewhat more, the difference is not likely to be sufficient to affect any general conclusion respecting the merits of the several plans proposed for the radical improvement of the navigation.

Two modes were proposed for storing up this immense body of water. One by means of numerous smaller dams, making reservoirs on or near the head-waters of the tributaries; the other by fewer large dams. The projectors and advocates of these modes, in order to show to others, as they believed themselves, that it was easily practicable to obtain this quantity of water, and easy to control it, presented certain assumed data, and laid down certain axioms bearing upon the question. The chief of these may be quoted as follows: "Can we find six reservoir sites upon as many creeks, each draining a basin equivalent to forty miles long by fifteen miles wide?" "Can proper locations be found at the lower ends of these basins for the six dams necessary to form six lakes, commanding each a drainage of 600 square miles? Or for a greater number of lakes of equal aggregate capacity? For the present we will assume (what we do not doubt,) that six suitable sites can be found, and that six dams can be erected, each ponding back or giving an annual available capacity of 25,000,000,000 of cubic feet of water."

My personal engineering knowledge of the region, acquired from many years' experience, has enabled me to investigate this point so as to refer to it in a practical manner, to some extent, without new surveys. In

making an examination of the merits of the several plans for improving the Ohio, I endeavored to look carefully to the difficulties and objections natural to each. This examination led to the conclusion that the premises laid down for these projected lakes, on the creeks, *cannot be found combined anywhere*—not in a single instance.

The combination required was or is an area of country draining 600 square miles, a fall not over about four feet per mile for the stream, a place below this basin to be drained where a dam 100 feet high could be erected, and a shape of ground so that its pond would contain the drainage of a year from the surface of the 600 square miles.

Mr. Ellet showed that an average of a number of years gave about 40 per cent. of the downfall of rain as available, but that in several years it was less than $33\frac{1}{3}$ per cent. Mr. Morris earnestly advocated, for the head waters of the Ohio, the assumption of 50 per cent. as reliable. I felt constrained to coincide with the judgment that it was not safe to rely upon more than about $33\frac{1}{3}$ per cent. Upon the quantity of water assumed above, this would demand *nine* lakes of the size designated.

The proposition was that such "sites might be found near or upon elevated grounds, with moderately steep water-sheds of ordinarily impervious material," and so situated that a dam 100 feet high would pond back 25 miles, and hold 25,000,000,000 of cubic feet of water.

In the first place there is no *creek* tributary to the Alleghany or Monongahela River that drains 600 square miles, excepting French Creek, which has as little fall as 4 feet per mile, and French Creek, owing to causes that will be referred to, is entirely unavailable. On Red Bank Creek, or river, as it is often designated, a dam even at its mouth would not flow back more than a little over half of 25 miles, owing to the fall in the stream, ($7\frac{1}{2}$ feet per mile,) and a dam 100 feet high would not pond more than about one-sixth of the assumed quantity.

The Clarion River, a principal tributary of the Alleghany, drains sufficient territory, say 1,400 square miles; but even this stream does not possess any other of the necessary assumed characteristics for one of the proposed lakes, for it rises even on its lower part $6\frac{1}{4}$ feet per mile, and on its upper part, from Ridgway up both its forks, from 7 to 50 feet and more per mile, with no flat places either on itself or on any of its branches, while its valley is so narrow that a dam 100 feet high, anywhere on the Clarion River, would not pond one-fourth of the assumed quantity. Above Pittsburg there are but five tributaries of the Alleghany that drain 600 square miles, namely, the Kiskimintis, the Clarion, the Red Bank, French Creek, and Connewango Creek.

The Kiskiminetas River (entering 28 miles above Pittsburg) has a fall of nearly 4 feet per mile; a dam 100 feet high would pond back about 25 miles, but its general valley is confined. At an average of 50 feet above present low water it may be about 1,200 feet wide. A reservoir on this part of the stream might contain, including the flow back along its tributaries, about 8,000,000,000 cubic feet, or say one-third of the assumed quantity for one reservoir. This is the part of the river where the least damage would be done by the construction of a dam 100 feet high. But even here it would submerge 20 or more miles of the Northwestern Railroad, and destroy not less than 20 valuable salt wells, several considerable towns, Leechburg, Warren, Saltsburg, or at least two of them, and several valuable water-powers. Further details of damages, &c., are not deemed necessary in this place. The Conemaugh River, above Blairsville, falls about ten feet per mile. The Connewango Creek drains about 960 square miles. The distance from Chautauque Lake to Warren, following the Cassadaga and Connewango Creeks, is

about 29 miles, and the fall 119 feet, or something over four feet to the mile. Chautauque Lake drains but a small area of country. A dam, to be 100 feet high, would have to be erected within four or five miles of Warren. It is not probable that such a dam would contain more than half of the assumed quantity for one reservoir; but the railroad and oil interests through that region of the Alleghany waters, from a point below French Creek to the Connewango Valley, would forbid the construction of such a reservoir there at the present day.

The general result of such preliminary examinations as I have been enabled to make in connection with this immediate investigation is, that on no tributary of the Alleghany can a place be found where a dam 100 feet high would be likely to pond more than half the assumed quantity of water for one reservoir.

Taking the other confluent, the Monongahela River, considering first the Youghiogheny, its main easterly tributary, we find that its upper part is unfit for reservoir or lake purposes on a large scale, on account of its very rapid fall, which is over ten feet per mile. In order to obtain the drainage of 600 square miles the dam would have to be as low down as its passage through Laurel Hill Ridge; but here the fall is ten feet per mile. A dam 100 feet high would therefore back the water only ten miles, and the pool would not probably contain more than one-fourth the entire drainage of 600 square miles. It is obvious from the fall in this river that it is not favorable for this particular plan of reservoirs, unless the dam should be located on the Lower Youghiogheny River, near its mouth, where a dam 100 feet high might flow back, say, about 40 miles, and make a pool which might contain, including the flow up its tributaries, about 15,000,000,000 cubic feet, or six-tenths of the quantity assumed for one of the lakes; but the railroad, coal, mill, farms, and town interests would cause enormous damages to be assessed, even if the people would permit its erection.

Cheat River is still more unfavorable even than the Upper Youghiogheny, on account of its fall.

We have next the main river Monongahela, or its westerly fork, a Virginia stream, until it enters Pennsylvania, about 90 miles above Pittsburg. The fall from Weston, Virginia, to the mouth of Cheat River is only about two feet per mile. There cannot be a doubt that here will be found one of the most favorable natural locations for the construction of a high dam which would flow over an extensive area and afford a large supply of water.

The construction of such a dam would, however, involve the necessity of some arrangement for passing rafts and other descending craft, or compensation in some form; matters which need not be entered into more particularly in this place. If these artificial lakes are to form a part of any system for the permanent improvement of the Ohio, I have no doubt that a site somewhere along this portion of the valley of the Monongahela would be selected for one of them. There is one other place where nature seems to have shaped the ground and the strain favorably for such a purpose. It is on the upper part, but not the extreme upper end of the Alleghany River, in the vicinity of the State line between Pennsylvania and New York. The drainage does not quite come up to the assumed area of 600 square miles; it would, however, be about 500 square miles. Here is an advantageous site for one of the proposed high dams, as the hills approach within about half a mile of each other, and the valley immediately above widens out and continues wide, with low bottom lands, and the fall in the river and on Potato Creek is only about two feet per mile, forming a peculiar flat

place in the Alleghany. Here, as in the case of the Monongahela, the river runs north, contrary to the general drainage of the country west of the Alleghany Mountains, which, in both instances, has the effect of greatly reducing the fall per mile.

But the construction of such a dam on the Upper Alleghany would destroy all the towns, mills, houses, and farms, in the valley above the dam for even thirty miles, including Smithport, the capital of McKean County, Eldred, Kingsville, Sharon, Alleghany, Millport, &c.

Independently of damage to the improvements made by man, this location would probably be the most advantageous of any to be found on the head-waters of the Ohio. If we allow a dam ninety feet high to flow back on thirty miles, an average depth of forty feet, on an average width of three-fourths of a mile, the quantity provided would be 25,090,560,000 cubic feet; adding one-third for the additional flow up the tributaries, 8,363,520,000 cubic feet—total, 33,454,080,000 cubic feet.

Upon the assumed average of twelve inches available downfall of rain per annum, for this part of the country, the total quantity on the five hundred square miles of basin would be 13,939,200,000 cubic feet, or less than half of the probable capacity of the reservoir assumed; consequently a dam much less than ninety feet in height at the point indicated would suffice to contain the drainage. A dam sixty feet high might flow back an average of, say, twenty-five miles, seven-tenths of a mile wide, with an average depth of twenty feet, which would contain 9,757,440,000 cubic feet; add one-third for the flow up the tributaries as before, 3,252,480,000 cubic feet—total, 13,009,920,000 cubic feet.

These rough approximations can, of course, only serve to aid in elucidating general features. My inference would be that a dam on the Alleghany about sixty feet high, near the State line of New York, might form a pool that would contain the drainage above it; and that its capacity would be about half of one of these six lakes assumed by the projector and advocates of the reservoir system, as easily practicable. Surveys alone made specially in view of reservoirs can afford accurate data.

In 1851 a survey was made by E. Lorraine, esq., civil engineer, for a reservoir on Anthony's Creek, in Virginia, for the James River and Kanawha Canal. The following data relating to that survey were furnished some years ago by Elwood Morris, esq., civil engineer, when advocating Mr. Ellet's plan:

Length of pool, 9 miles; perimeter, 46 miles; average width, $\frac{1}{2}$ mile; area of pond, 2,753 acres; gathering ground, 65,160 acres; mean depth, (assumed,) 60 feet; height of dam, 126 feet; length of dam, 395 feet. Level of outlet tunnel 30 feet below surface of pond. Contents available in 30 feet deep, or as low as the level of the outlet tunnel, 2,948,106,510 cubic feet.

It is possible that the assumption of 60 feet as the average depth is too great; but the other features of this locality certainly show that it is a remarkably favorable site for a reservoir. The basin drained being 102 square miles, and allowing no more than 12 inches per mile annually of available rain-fall, the quantity would be 2,843,596,800 cubic feet; so that the capacity of the reservoir would be greater than the annual supply. Probably the rain-fall in that part of Virginia is greater than the average on the Upper Ohio, so that it might not contain more than would fall during some years. I refer to this Anthony's Creek reservoir for a special purpose, not because it could possibly be made available in supplying the Upper Ohio River, for it could not be, but because it presents much more advantageous features than can be

found combined on any of the upper tributaries of the Monongahela or Alleghany Rivers. It was adduced by the advocates of the reservoir plan, for the purpose of showing how large a quantity of water might be stored up on a single tributary, and referred to as a basis for forming a general opinion of the approximate cost of securing reservoir supplies of water for the Upper Ohio River. On the other hand, the same parties presented an existing reservoir on the head-waters of the Conemaugh River in Pennsylvania, which is in the very region whence artificial supplies of water for the Upper Ohio must be derived, as showing what had already been accomplished on a small scale, compared with the much larger requirements for the Ohio River. The Conemaugh reservoir has a water-raise of 62 feet, with a capacity of 466,000,000 cubic feet. The Conemaugh reservoir is therefore only about one-sixth of the available capacity of the upper 30 feet of the Anthony's Creek reservoir, the latter having 126 feet water-raise, being double the height. Except in the two peculiar cases already described on the Upper Monongahela and the Upper Alleghany, where their courses are northwardly, diametrically opposite to the general drainage of the territory west of the Alleghany range, the head-waters of the smaller tributaries have in nearly all cases ten feet or more fall per mile; even Anthony's Creek, at the proposed reservoir, having 14 feet per mile fall. Very few, if any, sites so advantageous as that on Anthony's Creek, except the two on the main streams just mentioned, are likely to be found on the upper tributaries above Pittsburg. Few if any places occur where it would answer to erect dams 126 feet or even 100 feet high that would command drainage enough, and have the capacity of the Anthony's Creek reservoir. I make this suggestion not merely on any general view of the case, but from particular personal knowledge acquired through numerous surveys made for railroads, and in connection in former times with the Pennsylvania State Canal, between Johnstown and Pittsburg, the Erie Canal, between Erie on the lake and Beaver on the Ohio River, the French Creek Canal and Feeder, and the Monongahela slack-water navigation, between Pittsburg and the Virginia State line. I was engaged for three years with several engineer parties in the field, in surveying along the head-waters of the Alleghany for routes for the Alleghany Valley Railroad, and more recently, in 1865 and 1866, surveying routes for the Atlantic and Great Western Railroad, in the region between the western slopes of the Alleghany Mountain and the Alleghany River, and my professional duties at one time (in 1839 and 1840) required me to traverse the entire width of the State of Pennsylvania frequently, between the lake and the Virginia State line. It is due to the Department, as well as to myself, that the grounds on which these opinions upon this important subject are based should be known. It should be understood that they have not been formed in a random manner, but have the solid foundation of practical experience in the region in question.

It is quite possible that some sites for reservoirs, with dams fifty or sixty feet in height, more favorable than the Conemaugh reservoirs, exist, where the same amount of work would secure a larger supply of water, but they cannot be numerous. That reservoir cost \$166,000, and it was built many years ago, at a time when such works could be erected for about half their present cost. The same work would now cost probably not less than \$300,000. Admit that in similar situations \$300,000 might secure 500,000,000 cubic feet of water; I have seen no estimate of the cost of the proposed Anthony's Creek reservoir, but suppose it to be assumed roughly in round figures at no more than \$1,000,000, and al-

low that it might be large enough to store up 5,000,000,000 cubic feet of water, which is probably as much as it could hold and nearly twice as much as one foot of rain-fall on the basin drained, (65,160 acres :) to secure 150,000,000,000 cubic feet for the six-foot navigation with the Conemaugh reservoir as a basis, it would require 300 reservoirs, which, at \$300,000 each, would be \$90,000,000. To secure the same quantity with the assumed Anthony's Creek reservoir as a basis, as above, would require thirty reservoirs, which, at \$1,000,000 each, would be \$30,000,000; the latter being but one-third the cost of the former. I think it is safe for all present purposes to assume that to secure a quantity of water sufficient to maintain a flow in the Ohio River at all times six feet depth, would cost not less than \$60,000,000, because, although a few sites might possibly be found more favorable than that at Anthony's Creek, it is highly improbable that on an average, for thirty sites, the conditions would be anything like so favorable. Indeed, without extensive surveys previously made, no engineer would be justified in assuming, as a certainty, that the average conditions would be materially more favorable than those appertaining to the Conemaugh reservoir; in which case the cost might approximate to \$90,000,000 or more, as shown.

All this is, of course, founded on the assumption that it is practicable to find the number of sites required where the construction of such reservoirs would be permissible as well as practicable.

These approximate estimates, although presenting nothing accurately, may serve to convey a general idea of the probable cost of carrying out a system of reservoirs of sufficient capacity to maintain the flow of the Ohio at or near the depth of six feet in the channels of the natural river. Should such a system be adopted, the reservoirs or some of them would have to be found in West Virginia, in the northern part, but chiefly in Western Pennsylvania, along the head-waters of the Monongahela and Alleghany Rivers, and their tributaries.

MR. HAUPT'S LETTER.

PHILADELPHIA, *February 5, 1867.*

SIR: In your note of 21st ultimo you requested a summary of my views in connection with the plan proposed by me some ten or twelve years ago for the improvement of the Ohio River.

On the receipt of your communication I mailed to your address a copy of a pamphlet published by me in 1855, in which I reviewed some of the plans that had been previously proposed by others, and gave a brief outline of my own. At that time my official position in connection with the Pennsylvania Railroad, as general superintendent, and also chief engineer, and my desire to advance the prosperity of my native city, Philadelphia, led me to take a very deep interest in the improvement of the Ohio. I prepared and procured the passage of an act, which was approved on the 7th day of May, 1855, incorporating a company for the improvement of the Ohio River, and obtained subscriptions to the capital stock to a sufficient extent to secure the letters-patent, which are now in my possession. It was my design to procure, if possible, the action of the other States bordering on the Ohio River, and of Congress, and then proceed with the improvement, but professional engagements having called me to another State, where I have resided for about eight years, all further efforts in this direction were suspended.

I am greatly pleased that the attention of the General Government is again directed to the important subject of providing a permanent navigation for the Ohio, and also that the duty of reporting upon plans has been intrusted to one so well qualified to do justice to the object. I will therefore very cheerfully add to my printed review such remarks as may tend more fully to elucidate my plans.

CONDITIONS TO BE FULFILLED.

The desiderata in the improvement of the Ohio River appear to be—

1. A depth of water at all seasons sufficient for the ordinary purposes of navigation; say not less than five feet.
2. A breadth of channel sufficient to permit the ordinary floats to pass with facility.
3. An open and unobstructed channel, free from the delays and inconveniences of locks.
4. A mode of improvement that will not cause the formation of bars or similar obstructions.

5. An improvement, other things equal, which can be constructed at a minimum of cost, and maintained at a minimum of expense.

The plan of improvement which I proposed depends on the application of two very simple principles.

First. The quantity of water flowing in a channel being supposed constant, if the width of the channel be diminished the depth of water will be increased.

Second. The other data remaining the same, if the inclination of the bed be reduced the velocity will be diminished and the depth of the stream increased.

APPLICATION OF PRINCIPLES.

If it be desired to improve and render navigable a stream, the normal condition of which in low water exhibits a succession of pools with slight current and sufficient depth, connected by shoals or ripples over which the water flows rapidly and with insufficient depth, it is evident that the plan of improvement required is one which, without materially disturbing the pools, will increase the depth of water over the shoals.

By contracting the channel the depth can be increased to any extent, but the practical limit is, that contraction shall not be carried to such extent as to leave a width insufficient for the required navigation.

A body of water with a fall of one foot per mile, covering a channel 1,600 feet wide, an average depth of one foot would fill a channel 200 feet wide, and having the same fall per mile, to a depth of about four feet, if flowing at twice the velocity.

The contraction of the channel can in general be most readily effected by a bank of earth protected by a riprap of stone, the general direction of the bank being parallel with the shore, but avoiding sharp turns. The distance from the shore of course to be determined by the required width of channel.

The second principle on which I rely for increasing the depth is by a reduction of the slope of the bed, or the fall per mile. It is evident that if the velocity of the current could be reduced to one-half, the quantity of water and the breadth of the channel being constant, the depth would be doubled.

The velocity is in proportion to the square root of the fall per mile, so that to reduce the velocity to one-half, the fall must be reduced to one-fourth.

To reduce the inclination it would in general be very expensive either

to excavate or fill up the bottom of the channel to the required grade; but fortunately this is not required, as it would be in grading the road-bed for a railway. It is only necessary at proper intervals to throw across the channel low banks, the tops of which will be in the plane of the prepared grade. This will answer nearly the same purpose as continuous filling; in fact, the little pools of dead water between the transverse banks will form a water filling almost, if not quite, as efficacious as earth.

The diagram represents a longitudinal section of a contracted and graded channel; A, C, B, the original bed of the stream; A, B, the new or graded bed. Instead of solid filling to the plane A, B, low transverse banks are placed at intervals of 500 to 1,000 feet, connecting the longitudinal banks with the shore, and terminating in the plane A, B.

My plan for improving the navigation of the Ohio and similar streams consists chiefly in the judicious application of these two modes of increasing the depth, viz, by reducing the width of the channel, and the inclination of the bed. Of course, there is a limit to the reduction in the width of the channel, depending upon the character of the navigation. Forty feet might be sufficient for canal-boats, and three hundred feet scarcely sufficient for steamboats with their floats.

It does not follow that in projecting plans for the improvement of the Ohio it is necessary to conform to the present mode of open-river navigation, and seek to pass floats of coal-barges with a frontage of 150 or 200 feet, requiring for safe clearance a channel nearly five hundred feet wide. It would, of course, be impossible to construct locks of such width; and on the Monongahela only a single pair, or at most two pairs of coal-barges can pass the locks at one time.

A steamboat carrying a barge on each side, four in front, and four in rear, would tow ten barges; and the number could be increased to fourteen, with a front of not more than 100 feet. For two such floats to pass each other, the minimum width of channel should not be less than 250 feet.

I desire here to present a very important practical suggestion, which is, that no very serious inconvenience would result from contracting the channel occasionally, for short distances, to 125 feet, wide enough only for a single float, and then enlarging to the ordinary dimensions. Such contraction would permit the navigation to be maintained with little more than one-half the quantity of water required in a channel of a uniform width throughout, sufficient for two floats.

When the minimum width and depth have been determined upon, so as to conform to the requirement of the proposed navigation, the fall of the stream being also known, it then becomes a very simple problem to determine the required quantity of water, and if sufficient is not furnished by the stream, recourse may be had to reservoirs. These reservoirs may be of two kinds, either or both of which may be employed.

1. Reservoirs upon the tributaries, as proposed by Mr. Ellet, but of much smaller capacity than his plan required, would render these tributaries navigable by means of locks and dams, and would also furnish the requisite supply for the contracted channel in the main stream.

2. The second class of reservoirs which formed part of my plan in 1855 would be constructed by raising the dams required to throw the water into the contracted channels to a greater height than would be requisite simply to secure the required minimum depth, and contracting the outlet from these dams into the canal to an extent sufficient only for a single float, say 125 feet. In this way a sheet of water three or four feet in depth, and covering the whole surface of the pool, could be held

back and compelled to flow off very gradually, and each dam would thus subserve the double purpose of forming a reservoir, and of deflecting the volume of the stream into the contracted channel or canal provided for it.

This system of improvement will not lead to the formation of bars or other injurious deposits, for in time of flood the turbid waters sweep over the whole original bed, unobstructed by the low dams which, in times of drought, deflect the water into the canal. When the water is low enough to be confined to the canal no sediment would be carried in suspension, and no deposits could be formed.

This plan of improvement will involve less expense, both in construction and maintenance, than any other that has been proposed.

Time will not permit me at present to do more than give a very general idea of my views in regard to the improvement of the Ohio. I have described a plan which I suppose would be generally applicable, but in the execution of the work it will, of course, be necessary carefully to study localities, and vary the plan as circumstances may require.

In the hope that this hastily-written explanation may be intelligible, I remain yours, respectfully,

H. HAUPT.

WILLIAM ROBERTS, Esq.,

Superintending Engineer Ohio River Improvement.

MR. HAUPT'S PLAN CONSIDERED.

In justice to Mr. Haupt it may be proper to quote certain portions of his interesting pamphlet, published in 1855, having reference to his plan for improving the navigation. Much that is interesting in that pamphlet must be omitted here, my object at present being merely to present the plan in such a practical shape as to convey a clear idea of it, of its probable cost, cost of maintenance, probable action, advantages and disadvantages, as compared with other plans.

Mr. Haupt, after referring to a system of high dams and locks, with lifts of fifteen feet—that is, more than double of the height already proposed and examined in this report—remarks:

The case which has been considered is that of an application of the ordinary slack-water principle by means of high dams and locks. The objections to it appear to be numerous and formidable, but not insurmountable; and the importance to the general interests of the country, of an uninterrupted navigation, would be sufficient to justify the expenditure, even if it were quadrupled.

But before the adoption of such a system of improvement, although apparently more popular at this time than any other, it would be proper to inquire whether no other plan can be devised which will secure the desired object with fewer attendant disadvantages. A system of low dams, with chutes of very moderate inclination, would be free from the delays of lockage; would oppose less obstruction to floods; would be less expensive in first cost, and less expensive in operation, and would throw but little impediment in the way of descending coal and lumber trade. These are essentially important considerations, and the practicability of the plan deserves a serious consideration.

Mr. Haupt discusses the question of water-supply for this plan of low dams and chutes, and proves that for an opening 200 feet wide, through a chute one mile long, with the difference of level above and below of four feet, the discharge would exceed the low-water supply:

The discharge through an opening 200 feet wide and 6 feet high, with a velocity of $6\frac{1}{2}$ feet per second ($2\frac{3}{4}$ miles an hour,) will be 7,800 cubic feet. The actual discharge of the stream at low water being (as assumed by him) 2,500 cubic feet, the difference will be 5,300 cubic feet per second.

A discharge of 7,800 cubic feet per second is equivalent to 675,920,000 cubic feet per day, which corresponds with a depth of $4\frac{1}{2}$ feet on the Wheeling bar.

The longest interval during which this deficiency of 5,300 cubic feet per second may be supposed to continue is about two months. To supply this deficiency will require 27,475,000,000 cubic feet.

It is extremely doubtful [in the estimation of the writer, Mr. Haupt] whether reservoirs of such capacity can be formed upon the smaller streams until a more careful examination may establish the fact that the only system of reservoirs, applicable at the present day (1855) to the abatement of the floods in the Lower Ohio and Mississippi, will be by surface pools in the rivers themselves, formed by raising dams to a greater height than is required for the purposes of navigation, as previously explained.

The supply of water furnished by the river being insufficient to fill a chute of the dimensions required, it is necessary either to supply the deficiency by reservoirs or reduce the velocity by a change of inclinations.

We therefore propose to determine the inclination by the condition that a discharge of 2,500 cubic feet per second shall fill a chute 6 feet high and 200 feet wide.

The mean velocity of discharge, in this case, will be two feet per second. The fall would be five inches per mile, and the chute would become a continuous canal extending from one dam to the next, which is precisely the result that should have been anticipated, as the quantity of water discharged is not more than would fill a canal six feet by two hundred, with a fall equal to the average fall of the stream.

If it be assumed that the length of the canal will be two miles, the fall per mile will be two feet; the velocity of discharge 4.35 feet per second, or 2.9 miles per hour, and the discharge per second 5,220 cubic feet; leaving 2,720 cubic feet to be supplied at the lowest stage. To insure this supply, will require a reservoir capacity of 14,000,000,000 cubic feet. * * * It is certain that without any reservoirs whatever, using simply the low dams and chutes, a six feet navigation could be maintained whenever there was a depth of three and a half feet in the ordinary channel. * * * By reducing still further the slope of the channel which forms the communication between the pools the discharge would be lessened, and with it the quantity of water necessary to maintain a constant navigation.

It may be interesting to present the problem which has been under consideration, in a modified form, and, assuming the fall of the channel to be only one foot per mile, to calculate therefrom the velocity of the current, the whole discharge and the reservoir capacity required to supply deficiencies at the lowest stage:

The formula $V = \frac{1}{8} \sqrt{R \cdot h}$, in which $R = \frac{1200}{212} = 5.2$, gives for the velocity in feet per second 3.13.

The discharge with this velocity would be 3,756 cubic feet per second. The discharge at a two-foot stage at Wheeling being 2,500 cubic feet, the difference which must be supplied by reservoirs would be 1,256 feet. The stage of water that would furnish 3,756 cubic feet per second, at Wheeling, is two feet eight inches. Whenever the quantity of water in the Ohio would be sufficient to give a depth of two feet eight inches on the bar at Wheeling, there would be sufficient to maintain six feet depth of water in an artificial channel 200 feet wide, flowing 3.13 feet per second, or two and one-tenth miles per hour.

It will correspond very closely with the results of observations to assume that a stage of water below two feet eight inches rarely continues as long as six weeks, and during that period the average is not below two feet. The difference between the discharge at two feet and at two feet eight inches is 1,256 cubic feet per second, or 4,560,000,000 cubic feet in a period of six weeks. A reservoir one-third of a mile wide and an average of ten feet deep must be 58 miles long to contain this amount. A reservoir of this extent, which is only one-tenth of that proposed by Mr. Ellet, might be obtained without difficulty by slack-watering the Alleghany River, using the pools both for navigation and for reservoirs, and constructing additional reservoirs at the sources of the Monongahela and the Youghiogheny. It is unnecessary to enter into an examination of the improvement which consists in constructing a continuous bank for the whole distance from Pittsburg to Cincinnati, forming a contracted channel of sufficient width to maintain a uniform minimum depth of six feet. This plan is no doubt practicable, but the cost would be more than double that of alternate pools and channels, and the advantages not so great.*

* It is obvious that from Pittsburg down for some distance the mound would necessarily be continuous, on account of the rapid fall in the stream. Thus between Pittsburg and Beaver, 26 miles, where the fall is fifteen inches per mile, even a continuous mound or bank would not reduce it to the average of twelve inches per mile; and the entire average from Pittsburg to Wheeling, 90 miles, is about ten inches per mile, and between Beaver and Wheeling, 64 miles, it is about nine inches per mile. Mr. Haupt, at page 47 of his printed pamphlet, refers specially to the fall between Pittsburg and Wheeling, in order to show that with the water at a two-foot eight-inch stage at Wheeling the aid of artificial reservoirs would be required, or a portion of slack-water on that part below Pittsburg.

Mr. Haupt goes on to remark, page 44 of his printed pamphlet :

The opinion is generally entertained that the plan of improvement by the construction of a slack-water navigation is the only one practicable. It is almost unnecessary to remark that this is not the opinion of the writer; he is satisfied that the true plan for the best improvement of the navigation differs from any that has yet been proposed, and consists of a succession of pools formed by low dams of from six to ten feet, connected by open channels not less than 200 feet wide, through which the water will flow, free from locks or any other obstruction, at the moderate velocity of two miles per hour. * * *

In the construction of the improvement, the dams could be so located as to form slack-water and capacious basins at all the principal towns on both sides of the river, and the open channels should, of course, be made where the fall of the stream is greatest. * * * It will no doubt be offered as an objection to this plan that the banks will be liable to injury from floods and from ice freshets. To this it may be answered that they lie not across but in the direction of the channel; that the current is always moderate; that the exposure would not be as great as that of the canal banks on the improvements along the rivers of Pennsylvania, which are rarely injured even when entirely submerged; and that a coating of stone, placed by hand, upon the slopes, will be an effectual protection. The facilities for obtaining and transporting all kinds of material upon the river would reduce the cost of the banks within moderate limits, and no mechanical work would be required upon the whole improvement, except at the dams, where it would be of the most inexpensive character.

By making the banks ten feet high the period during which they would be submerged, or in which the depth of water was not less than ten feet, appears from the record to have been as follows :

In 1843.....	123 days.
In 1844.....	76 days.
In 1845.....	51 days.
In 1846.....	104 days.
In 1847.....	124 days.
In 1848.....	97 days.
	<hr/>
	485 days.
	<hr/>
Average days each year.....	81

The course of the embankment should be marked by buoys, to prevent boats from coming in contact with it. There is, however, but little danger from this cause, as the shore would always be a certain guide—the direction of the bank being parallel to it. * * * If a slack-water be adopted between Wheeling and Pittsburg, the dams could be made high enough to act as retaining reservoirs, to supply the channel below Wheeling, but it is probable that the advantages of a perfectly free and unobstructed navigation would give a preference to the Alleghany as the location of the reservoirs, leaving no locks below Pittsburg, unless they should be required at some of the great falls, as at Louisville, where it is not probable that any other plan could be successful. If it should appear, after a careful survey and examination, that locations can be found on the streams above Pittsburg of greater capacity than we have supposed probable, and if these reservoirs can be constructed at moderate cost, this fact should modify the plan of the improvement, and the channels which connect the pools could be made either wider or shorter. An increase in width retaining the velocity of two miles per hour would be preferable to a reduction in length, but it would of course be more expensive.

Mr. Haupt, in offering his plan for public consideration, stated that he had confined himself to general principles, without entering into details of location of works and estimates of cost. In a general way he assumed that it would cost less than the slack-water plan. My investigation of the question of cost leads to the conclusion that the first cost of a system of the kind perfected on the whole length of the Ohio would exceed the first cost of the slack-water. The annual cost of keeping it up would, however, be much less for the ordinary supervision of the dams and mounds, but occasionally there might be extraordinary expenditures in connection with the reservoirs, the mounds, or the embankments in the river, and for the clearing out of the two-hundred-foot channel in cases where tributaries should, in times of flood, carry into it gravel, stones, logs, &c., requiring the operation of dredging.

There are several serious difficulties or objections to the plan which

it is proper to offer for consideration: 1. This plan of canals and low dams, with the canal on but one side of the river, if it afforded a good navigation on that side, would cut off or greatly inconvenience the inhabitants on the other side, in consequence of the dams and the long mounds along each pool, together constituting a *cul-de-sac*. To reach any place above and near to a dam on the opposite side from the channel, steamers would be forced to "double the cape" of the mound, whatever number of miles it might be from the dam to the end of the mound. And between Pittsburg and Beaver, upon the premises assumed, the canal would necessarily be continuous for twenty-six miles; and thence to Wheeling, sixty-four miles, it would require mounds to cover a large portion of the distance. This difficulty might be remedied partially, when there should be slight floods, by means of movable sluice-ways in the dams; but in low water and in moderate stages of the river, the objection would remain in full force. 2. The canal being only two hundred feet wide, no descending steamers could round to for landings, and many steamers which are more than two hundred feet long could not turn in it at all; and as both ascending and descending steamers and tows would be constantly moving in opposite directions in these long, narrow channels, extending for miles, there would be imminent danger of collisions. The present system of fleets of coal barges could not be carried on through such long, narrow, and in many places, as they must be, curved channels, even if the fleets were arranged with much less frontage, which itself would be a pecuniary loss to the river trade. 3. The accumulation of sand, gravel, stones, &c., immediately opposite the mouths of tributaries, pouring across this narrow canal, would often obstruct, and, for the time, and until removed by dredging, &c., destroy the navigation. In some cases, it is true, the tributaries might enter the main stream in the open spaces between the mounds. In other cases they would undoubtedly enter into the canal part, and be either turned down the canal or pass in floods in part over viers constructed in the mounds, to the main Ohio.

I apprehend that, on a critical investigation of the merits of the several plans proposed for the radical improvement of the river, the objections here stated will prove to be very formidable, if not fatal to this plan of canal and mounds, even if the canal were three hundred feet wide.

A modification of the plan of low dams without locks, combined with the patent chute invented by Alonzo Livermore, esq., civil engineer, was deemed worthy of careful examination. I addressed a letter to Mr. Livermore, asking him to furnish, for the use of the Department, a descriptive report and estimates, &c., of his plan, which he has kindly done. He also brought a model of his patent chute, and explained it in the United States engineer's office in Pittsburg. In justice to him, and in order that the plan should be presented in the clearest manner, I offer, first, Mr. Livermore's report, to be followed with some views of my own on the subject:

PITTSBURG, *February 25, 1867.*

DEAR SIR: Your esteemed favor of the 12th ultimo I have carefully examined, noting each question in the order you have proposed, and now proceed to answer your interrogatories in due form. I hope to be able to explain satisfactorily to you the plan and operation of my "improved chute" for ascending as well as descending navigation. I return you my thanks for thus enabling me to lay before you, for public use, this improvement for overcoming natural and artificial falls in rivers

and large canals, superior, in every respect, as I think, to any plan heretofore proposed or adopted for this purpose.

My experience as a civil engineer has been extensive and varied; a large portion of my time, for nearly thirty years, was occupied in the construction of canal, slack-water, and steamboat navigation. I hope, therefore, from this cause, my plan will receive such attention as the circumstances would appear to merit. My desire is to have my invention thoroughly tested, in a model form, by practical and scientific engineers. All improvements of this kind, when carried out, are too expensive in their construction to expect any plan which is new and untried to be recommended or adopted, without preliminary trial by experiment and thorough investigation. I hope, therefore, to convince you and others that my plan is worthy of careful examination, by a reasonable trial, in such manner as shall be thought sufficient to test the truth or falsity of the premises which I have assumed as correct.

QUESTION 1.—*A description of the plan.*

In order to make my ideas as clear as possible I submit a plan or sketch of a portion of my "improved chute," as connected with an artificial dam in a river or water-course. Explanations and references accompany the plan, all of which you will find at the end of this report.

The object of my invention is to decrease the velocity and discharge of the water in a given channel, thus enabling boats and other craft, by reasonable power, to ascend as well as descent said channel, and at the same time maintain such a depth and width of water-way as shall insure continuous navigation at the lowest stage of any given water-course.

The nature of my invention consists in dividing the natural or artificial fall which it is desired to overcome, into several parts or smaller falls, and separating them by intermediate basins, pools, or chambers, said basins, pools, or chambers being enlargements in the cross-section of the boat-channel or chute, by increasing the depth and width greatly above the given size of the boat-channel. The length of these basins, pools, or chambers which divide the several falls may be increased or diminished to suit the desired inclination or grade of the proposed boat-channel. The fall between each basin, pool, or chamber should be fixed to suit the minimum quantity of water in a given river or water-course, as upon this point rests the calculation for the discharge and velocity of the water, and not upon the length of the pools, basins, or chambers. (See Venturi's experiments on the discharge of water through pipes with enlargements.)

The construction of the chute is, in the plan, represented as overcoming an artificial fall caused by a dam in a river or water-course. The end of the dam is shown in the sketch. The principle involved is the same for overcoming a natural fall. For a canal, or island channel, a river wall would be unnecessary; consequently, the construction of the chute would be cheapened. The guard or guide timbers are required to prevent boats and other craft from being thrown out of their course, and cause them to strike against the lips, or division walls. The entire fall for a given chute is to be divided by a series of falls, steps, or drop-pings from one basin, pool, or chamber, to another basin, pool, or chamber, and so continued until through the series the entire fall is overcome. These basins, pools, or chambers cause the water to flow mainly out of its direct course and expend its force in the enlarged water space. The lips and water-breaker aid in retarding the downward current of the water. These means prevent any accelerated speed of the

water in its course onward, as is the case in any of the common constructed chutes or water-channels. In addition, the lips cause a contraction of the current as it passes through the opening in each division wall, which, under all similar circumstances, greatly decreases the discharge through a given space and under a given head. From experiments of Poncelet and Lesbros, through thin vertical plates in the side of a cistern or reservoir of water, the discharge from still water is found for large openings to be not over 61 per cent. of the amount which theory would indicate; yet, if the water approaches the opening with any considerable velocity, a corresponding increase will take place in the coefficient for discharge. If we assume the approach to the overfall to be 12 inches per second, this should be added to the theoretical velocity before we apply the coefficient of discharge. For a 4-inch fall the theoretical velocity would be 4.633 feet per second; add the 12 inches, the theoretical velocity would be increased to 5.633. This coefficient must again be reduced by the contraction of the current caused by the lips. Experiments made by Eytelwein indicate that tubes projecting within the reservoir reduce the coefficient to 0.50 per cent. This coefficient, applied to the velocity assigned by theory, with the addition of the approach, would give only a practical discharge from a velocity of 2.82 feet per second. In order to guard against any under-estimate for the discharge, I propose to use the coefficient, 63 per cent. of the theoretical velocity of the head, offsetting the velocity of the approach against the counter-acting causes produced by the lips. It is hardly necessary for me to go into detail as to the plan of the dam. This does not change the construction of the chute. The estimate for the cost of a dam is here based upon one to be built on a gravel foundation, with a base of 50 feet and a height of 13 feet. From the foundation, six feet high, the work is calculated as vertical. This brings a seven-foot lift to the surface of the lower pool. The breast upon which the water falls should be very flat, not steeper than one foot rise to five feet base. The upper slope may be much steeper. Great care should be used here to prevent leakage. The plank should be doubled so as thoroughly to break joints.—a double row of sheet piling, well put down into the gravel, and a close joint made with the roof planking. It will not do to depend upon embankment, or gravel above a dam, as the most important means to prevent wastage of water. As it is calculated in low stages of the river that all the water may be needed, great care should be used, in the construction of the dam, to make it as nearly water-tight as possible.

QUESTION 2.—An estimate of the cost of one dam and chute, assuming 1,600 feet width of river, with 5 feet depth for navigation, and 7 feet lift from pool to pool; or say 12 feet height of dam, with 100 feet width for channel.

The following estimate of one chute seven-foot fall and a dam is based upon the present prices of labor and material. Six or seven years ago two-thirds of these rates would undoubtedly have been amply sufficient for the cost of the work. Instead of five feet depth of water, the dam is elevated sufficient to give six feet. But at a minimum flow of water of only 100,000 cubic feet per minute, the depth of water will be less, but not below the proposed five feet. The chute is calculated to give a slope or inclination of four inches per 100 feet; whole length of chute 2,100 feet, with a fall at each division wall of four inches. I do not recommend a fall greater than this amount, to each 100 feet. Where water is abundant, as upon the lower part of the river, the fall may be in-

creased to each division wall, but instead of shortening the length of the chute, I would increase the length of the basins, pools, or chambers, and decrease the number of division walls. For instance, if I propose to give six inches fall to each division wall, the number of these walls would be but 14, instead of 21, as in the calculation here submitted:

5,704 cubic yards masonry, laid in cement, at \$10.....	\$57,040 00
316,600 lineal feet crib timber, 6 by 12 inches, at 12½ cents.....	39,575 00
13,960 cubic yards stone filling, in cribs, at \$150.....	20,940 00
2,500 cubic yards slope wall protection, at \$200.....	5,000 00
12,000 cubic yards excavation of foundation, at 50 cents.....	6,000 00
420,000, board measure, plank facing, sheet piling, &c., at \$40 per thousand.	16,800 00
17,000 pounds iron bolts and spikes, at 15 cents.....	2,550 00
21,000 lineal feet guard timber, 6 by 18 inches, at 30 cents.....	6,300 00
Entrance crib protection above and below chute.....	6,000 00
Add for contingencies 10 per cent.....	16,020 50

Total cost of chute.....	176,225 50
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Estimate of dam 13 feet high, 1,350 feet long.

1,350 lineal feet of weir, at \$63 per foot.....	\$85,050 00
520 cubic yards masonry in abutment, at \$10.....	5,200 00
1,000 cubic yards excavation of abutment, at 50 cents.....	500 00
Protection crib below the dam.....	3,000 00
Add for contingencies 10 per cent.....	9,375 00

Total cost of dam.....	103,125 00
Total cost of chute.....	176,225 50

Grand total.....	279,350 50
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QUESTION 3.—Probable time required for completion.

Extensive and costly works, while being constructed within the channel of large rivers or water-courses, are liable to be delayed by floods. These may be more or less frequent some seasons than others, and also of longer or shorter continuance. The work upon a chute could be prosecuted under these difficulties with greater advantage than the work upon a lock. A much larger force could be employed in building than upon a lock at any one time. The dam for a chute navigation would scarcely ever be as high as for a lock. This would be owing to the greater length of the chute reaching farther down the stream to find the required depth of water. I think I am justified in saying that the difficulties of construction would be less with this kind of improvement than for locks and dams. I think it would be safe to calculate the completion of any one of this kind with ordinary seasons within two years.

QUESTION 4.—An estimate of the proportion of water to be saved, compared with a plain chute of same width, with declivity 4 inches per 100 feet.

The quantity of water required for a given depth and width does not so much depend upon the declivity as upon the number of division walls. A chute 14 feet long, with 21 division walls, will discharge but little if any more water than one 2,100 feet, with the same number of division walls. (See Venture's experiments upon enlargements in pipes.) The disadvantage in short chutes will mainly be the increase of gravity against ascending craft. This point will be more fully elucidated in my future answers to your questions. The comparison I shall make between the "improved chute" and the plain chute will be as you propose. The improved chute is to have 21 division walls, with a fall of four inches to each wall. Theoretically a four-inch pressure upon water

will give a velocity of discharge through an opening of 4.633 feet per second. The contraction of the current through rectangular openings causes a decrease of the discharge, and through large apertures the coefficient for practical discharge is reduced as low as 61 per cent. (See experiments of Poncelet and Lesbros, as arranged in tabular form by Neville.) The discharge here given in tabular form was for rectangular lateral orifices in thin vertical plates. For the improved chute, lips or up-stream prolongations are used to further decrease the discharge. According to Eytelwein, a tube projecting within a reservoir will reduce the coefficient to 0.50 per cent. The chute, however, has the disadvantage of a current before its approach to the overfall. This current must be calculated as accelerating the theoretical discharge; and as the chambers or enlarged parts of the chute are about three times the cross section of the boat channel, we may add twelve inches as the velocity of the approaching current. This would increase the theoretical velocity to 5.633, which, reduced by the coefficient 0.50, would reduce the discharge to 2.82 feet per second. I prefer, however, to use the coefficient 0.63 for the theoretical discharge under a four-inch head, and offset the advantages of a reduction by the lips to the disadvantages of the approaching current. The theoretical velocity of 4.633 feet will in this way show a practical velocity of 2.92 feet per second. In estimating the depth of the water in the improved chute at five feet, I use the surface of the water in the first pool or basin instead of the surface above the head of the chute. The depth for calculation of discharge will consequently be five feet four inches. This increase of depth will be requisite for the ascending boat that may be loaded down to near five feet, as will be obvious. From the foregoing data the discharge for a five-foot navigation will be found to be 93,340 cubic feet per minute, and in like manner for a six-foot navigation a discharge of 110,960 cubic feet.

By shortening the chambers, pools, or basins, and adding seven more division walls, the fall to each will be reduced to three inches. The discharge will be reduced for a five-foot navigation to 79,380 cubic feet per minute, and for a six-foot navigation to 94,500 cubic feet. The expense of the chutes will be increased about \$20,000.

For a plain chute 2,000 feet long, 100 wide, maintaining a depth at the lower end of three feet, I use the following equation for measures in English feet, reduced from Eytelwein's coefficient. (See Neville's table and formula, page 114.) Velocity equals $\sqrt{8976 \cdot r \cdot s + 0.012} - 0.109$. r . equals area of section divided by wetted perimeter; s . equals fall divided by the length of the channel.

The velocity per second by this formula is found to be 11.55 feet, consequently the discharge per minute for the plain chute will be 346,500 cubic feet. It will be seen, therefore, that the difference in favor of the improved chute is 253,060 cubic feet. Should we increase the division walls in the latter, the difference will be still greater.

QUESTION 5.—*Allowing one hundred thousand cubic feet as the practical minimum natural flow of the river, a calculation showing how much additional supply would be needed to maintain a depth of five feet in the channel, assuming the fall in the chute at four inches per one hundred feet, making the chute two thousand one hundred feet long, or, if it be preferred, six inches for one hundred feet, making it one thousand four hundred feet long: show the result on both lengths.*

The points in this question have mainly been answered previously. A chute 1,400 feet long, with fourteen division walls, having a fall of

six inches to each 100 feet, or each division wall, would require 117,810 cubic feet of water per minute to maintain a five-foot navigation. The six-foot navigation would require 141,230 cubic feet. The cost of this chute would be \$30,000 less than the one estimated. I would not, however, recommend this plan. By increasing the length of the chute to 2,100 feet, with fourteen division walls, the discharge would be the same as the 1,400-foot chute, or nearly; but the gravity of the ascending craft would be the same (if the boats or other craft had a length of two hundred feet or upward) as the four-inch fall, twenty-one in number of division walls. In this case, the cost of the chute would be reduced only fifteen or eighteen thousand dollars. This would probably be done upon the lower part of the Ohio River, where there was a sufficiency of water, and in such cases I would recommend the 2,100-foot chute, with but fourteen division walls.

QUESTION 6.—*Probable annual cost of repairs.*

Those parts of the work which are built of timber in whole or in part that are above a reasonable stage of low water, and hence liable to decay, will cost in their construction about \$20,000. If we assume that this work shall be renewed every eight years, the annual expenditure would be \$25,000. For all other repairs for chute and dam, I am confident that the annual expense will not exceed two per cent. of the estimated cost. Upon this basis the aggregate expense of the repairs per annum will then be \$8,087. The estimate is intended to include superintendence, &c.

QUESTION 7.—*Probable duration of works.*

From the foregoing you will see that the chute and dam are supposed to be kept in complete repair. Extraordinary damages may occur from unforeseen causes. Such incidents are common with works built in rapid water-courses. With care in their construction, such works are more safe in rivers like the Ohio, where the fall does not much exceed one foot per mile. It would be useless to attempt an estimate of such possible contingencies. Otherwise I see no necessity of limiting the duration of the works.

QUESTION 8.—*Effects on the general navigation during construction ; views connected therewith.*

The chute ordinarily would be built near and adjoining one shore of the river, and would not necessarily be placed in the way of the natural boat channel. It would be well to complete the chute somewhat in advance of the dam. It would then be available for navigation, in case the dam was in such state as to injure the natural course of boats, when floods might occur. The dam should not be pushed forward until such means as shall be sufficient are provided to keep up the navigation.

QUESTION 9.—*Risk of accident—probable effect.*

Without trial I cannot believe the use of the chute will cause as many accidents to boats and other craft as the lock. The water will flow gently, yet there will be counter-currents. Care will be requisite in the management of boats and other craft. By due caution, I think there need be no injurious accident. Bad management may cause injury or sinking of weak craft. This is the case sometimes in passing of locks.

QUESTION 10.—*General objections that might be urged to the plan.*

Owing to the inclination of the boat channel, the ascending craft or boat will have to contend against gravity in proportion to the inclination. For large boats, occupying one-fourth or more of the cross-section between the division walls, this inclination will be increased by the tendency to draw up at the bow of the boat from two and one-fourth to three, and one-fourth inches. Ordinarily the whole difference in the ascent of a boat of three hundred feet will amount to six inches, or two inches per one hundred feet; this, added to the four inches in the channels, will make the gravity six inches instead of four for each one hundred feet. In ascending grades upon railroads an engine expends one-half as much power in overcoming a grade of six inches per one hundred feet as it expends in drawing a full load upon a level road. A boat capable of propelling itself and load in still water at the rate of seven miles per hour, on account of the current this speed would be reduced in the chute to five miles per hour. In water the resistance increases nearly as the square of the velocity, the square of five being twenty-five, the half of which would be lost by the ascending grade. The boat would only under these circumstances be able to go forward about three and a half miles per hour, requiring nearly eight minutes to ascend the chute. Objections may be urged without due consideration to the amount of work exposed to the action of floods. While I freely admit the large surface necessarily occupied by the chute, I see no reason to apprehend serious damage by floods to any of the important parts of the work. The head and river wall, as far down as necessary, will be constructed of substantial masonry and raised above all the inside division walls or other work. The water will not go over this wall until the inside work is entirely submerged in the back-water. The division walls will then be under water from one to fourteen feet. The guard-timbers, lips, and supports for guard-timbers, will come within one foot at top of the head-wall, yet will be submerged this much before the water begins to run over. The only damage they can sustain will probably be from ice and driftwood, which may be carried through the boat channel. Even then the force with which the object would strike these works could hardly cause any material injury, nor could damages to this seriously interfere with navigation, neither would the repairs be expensive.

It is possible that objections may be urged against the plan by the supposition that the basins, pools, or chambers, will fill up with gravel, sand, and mud. This view I think untenable, because that the head cross-wall of the chute will enter the pool of the dam, where this cross wall will be elevated some feet above the bottom or bed of the river; and in comparatively still water gravel and sand will not rise several feet perpendicular in a slow current and pass over this wall. The mud that may be held in suspension will hardly settle while the water is in an agitated state, as will be the case while passing through the chute.

If objections are urged against the improved chute because of its cost, the same objections must lie against all radical improvements of the Ohio River, which propose a permanent depth of five or six feet, and a channel wide enough to pass the larger class of steamers. The estimate herewith submitted I believe to be liberal. It is based upon the present high rates for labor and material, which will more likely fall than rise in the future.

QUESTION 11.—*General advantages that may be urged in favor of its adoption.*

To contrast advantages, it will be necessary to state the kind of improvement with which I propose to compare it. In the first place, slack-water navigation by means of locks and dams is the most appropriate plan of improvement with which to commence my comparison.

Advantages of increased speed.—I have given the calculations for ascending craft up a chute 2,100 feet long. While it takes eight minutes to ascend, there is but *four minutes* of absolute loss of time, since this time would be consumed in traveling a similar distance upon an open river. In descending there will be no loss of time, yet in either direction there may be a delay caused by boats or other craft being in the chute, ascending or descending in the contrary direction. This may occur, say, one-fourth of the time. Add, therefore, one-fourth of eight minutes, equal two minutes, and also two minutes more for checking speed as the boat or craft enters the chute, we have ten minutes loss of time in passing each chute for the round trip. For locks the loss will probably average thirty minutes, or fifteen minutes each way. If we assume forty-six chutes and the like number of locks between Louisville and Pittsburg, to pass the chutes will require seven hours and twenty minutes. To pass the locks will require twenty-three hours, showing an advantage in the round trip in favor of the chute of fifteen hours and forty minutes.

The next important advantage in favor of the chute is the ability of giving an unlimited length to boats, rafts, and other craft in passing through the chute, while for locks the necessity of gates prevents this being done. Furthermore, locks must be limited in width even when there is an abundance of water. Beyond a given width the gates become too heavy and unwieldy for safety and speed in using. The chute can be extended to any width, perhaps even as much as 200 feet, when there is width of channel and plenty of water. Such situations for an extra width of chute will be found at rapids and large falls, as at the falls at Louisville, and Des Moines on the Mississippi. In these places the rivers are wide and probably afford an abundance of water, even for a chute 200 feet wide, with 6 feet depth in low water.

Another advantage I think will be found in favor of the chute, that the mud will be less likely to settle above and below the chute than above and below a lock. The water in the chute having a constant flow at all times, there will be but little chance for mud to settle. The lock gates at times being entirely closed, there will be more chance for mud to settle, and such I have found often to be a serious matter in certain localities where locks have been built.

There is a further advantage which at times may be important on the Ohio. On many streams it would be important every spring and fall. This is the unobstructed passage-way for fish. The advantage the chute would have over the lock in this respect I think is obvious, and needs no particular explanation here. As you expect to make a detailed estimate of the cost of a lock and dam, it may not be necessary for me to show the advantages the chute may have in this respect. I will, however, make a comparison by a single lock 80 feet wide and 400 feet between the gates, with the necessary dam and other works. This, perhaps, is the least size which would compare properly with the chute, which is calculated at 100 feet in width for the boat channel. I was engaged upon the Green and Barren River navigation in Kentucky, as chief and resident engineer. This improvement was completed about

twenty-five years ago. From the mouth of Green River to Bowling Green, on Big Barren, the distance is 175 miles, and the lockage 78 feet. The locks were built of cut stone, and laid in Louisville cement, except one, which was laid in common lime. They were built for steamboat navigation, 36 feet wide and 160 feet between the gates. There are five locks and dams, and they consequently average over fifteen and a half feet lift. The dams varied from 300 to 680 feet in length, and from 15 to 22 feet in height. The cost of this improvement, exclusive of some timber chopping upon tributaries, was \$780,000, or, upon an average, \$10,000 per foot-lift for a lock and dam. At the time these works were constructed, labor and material in general were fifty per cent. below the present rates; adding, therefore, fifty per cent., the cost of these works at the present time would amount to \$15,000 per foot-lift. For improvements upon the Ohio, (with locks 80 feet by 400 feet, and dams averaging 1,300 feet,) for a foot-lift, we will find just about three times the amount of labor and material as upon the Green and Barren River navigation. I think, therefore, a safe estimate will be for the Ohio River improvement, \$45,000 per foot-lift. It may, however, be necessary to make a double lock; perhaps the latter need not be more than sixty feet in width. As but one wall will be required for this extra lock, it is probable \$8,000 per foot will be sufficient to add, making for the whole cost \$53,000 per foot-lift. The chute has been estimated in answer to your second question, and the estimate is based upon prices which are fully fifty per cent. above the prices paid upon the works which were built in Kentucky. By this estimate the chute will cost \$40,000 per foot-lift, nearly, and if we add for an increased number of division-walls in order to decrease the discharge of water so that a six-foot navigation shall be maintained by a discharge of less than one hundred thousand cubic feet per minute, we may add a further sum of \$2,857 14 per foot, making the cost of the chute for a six-foot navigation, \$42,764 35 per foot-lift.

If my calculation of time in passing the chute and the lock be correct, the chute can pass three times as many boats or craft as a single lock in the same time, and fifty per cent. more than a double lock. The comparison of cost should, I think, be for a double lock, yet a single lock will cost \$2,235 65 per foot-lift more than the chute with all the accompanying works.

The other plans proposed for the improvement of the navigation of the Ohio River, and which deserve careful attention, are those suggested by Messrs. Charles Ellet, jr., and Herman Haupt, civil engineers of undoubted celebrity. The scheme of Mr. Ellet was proposed about twenty years ago. This plan was to build reservoirs of such number and magnitude upon all the great tributaries of the Ohio River above Pittsburg as to retain sufficient water from the superabundance afforded in times of floods, which, by being let out at proper times, should keep up a constant flow of not less than five feet in the boat channel over the bars below Pittsburg.

The consummation of this grand scheme would be an achievement worthy of the age. But the practical difficulties are of such magnitude that I fear the enterprise can never be accomplished. Extensive and elaborate surveys and estimates must first be made before its feasibility can fully be determined, yet we have some data that at present would appear to indicate the impossibility of attaining so grand an object, at any reasonable expense. The value of land has greatly increased since the project was first broached by Mr. Ellet. Within a few years oil has been discovered underlying large territories of land bordering upon many important tributaries of the Ohio. Many of these lands, which at that

time were comparatively of little value, are now rated at fabulous prices. Coal and iron ore have been discovered in many localities at that time unknown. Timber lands have increased ten times their former value. In short, the land necessary to be occupied for reservoir purposes, which at that time might have been obtained for \$1,000,000, would now probably cost fifteen or twenty millions. This item alone will probably in future be found to exceed the cost of the whole improvement of the Ohio River by means of the chute, as proposed by me. The cost of constructing reservoirs capable of retaining such a vast amount of water as will be required to maintain the proposed depth upon the shoals of the Ohio River, can hardly be approximated by any data now in my possession. I know of no person who is better acquainted with the topography of the streams and the country which supplies the Ohio with water than yourself. It would certainly be useless for me to enter into any problematical estimate on this subject. You will, therefore, excuse any further comparison at present of the chute scheme with the reservoir plan of Mr. Ellet.

The next plan proposed is that of Herman Haupt, esq., civil engineer, about twelve years ago. This plan, although somewhat indefinite in particulars, consists in general, as proposed by himself, in the attainment of the following conditions:

1. A depth of water at all seasons sufficient for the ordinary purpose of navigation, say not less than five feet.
2. A breadth of channel sufficient to permit the ordinary floats to pass with facility.
3. An open and unobstructed channel, free from the delays and inconveniences of locks.
4. A mode of improvement that will not cause the formation of bars or similar obstructions.
5. An improvement, other things equal, which can be constructed at a minimum of cost and maintained at a minimum of expense.

To obtain the object set forth by the enumerated conditions above specified, Mr. Haupt proposes low dams, and an open canal connecting each pool; the canal to be not less than 200 feet wide, with a fall in the canal sufficient to meet the requirements of the natural fall of the river, and not greater than necessary for this purpose.

In order to attain these desiderata, upon the plan of Mr. Haupt, it will be necessary to fix the fall in the canal at such a minimum as shall accomplish the purpose at the least expense and with as little water as may be requisite to keep up a depth of five feet in a canal 200 feet wide. The greatest fall for any considerable distance upon the Ohio River, except the falls at Louisville, is from Pittsburg to Beaver—the distance 26 miles and the fall 30 feet. Supposing the first low dam to be two miles below Pittsburg, the canal from that point to Beaver would be 24 miles. In order to overcome 30 feet fall, the canal must have a fall of 1.25 feet per mile. It will be best, therefore, to fix this as the minimum fall and maintain it for the residue of the river. With a canal on an average 200 feet wide, with side slopes of one and a half base to one perpendicular rise, five feet deep, with a fall of 1.25 feet to the mile, the velocity of the water will be 3.07 feet per second, and the discharge per minute will be 184,200 cubic feet. Taking off 100,000 cubic feet as the natural minimum flow, there must be provided by reservoirs 84,200 cubic feet per minute to supply deficiencies in low water. The distance from Pittsburg to the mouth of the Ohio, exclusive of the falls at Louisville, has been stated at 972 miles, and the fall 400 feet. Allowing a fall of five-eighths of an inch per mile for pools discharging 184,200

cubic feet per minute, there will be required 292 miles of canal and 680 miles of slackwater. The canal will overcome 365 feet of fall and the slackwater 35 feet. By careful calculation, I find the fall in the pools of five-eighths of an inch per mile is as much as will be realized at the low-water stage. The dams should be raised sufficient to give six feet of water in the canal whenever the natural flow of the stream will give the quantity required for this purpose. The quantity requisite to fill the canal six feet in depth will be 248,107 cubic feet per minute. The velocity per second 3.39 feet. It is not calculated that any water will be drawn from reservoirs until the water falls to five feet in the canal, or under, unless a six-foot navigation should be maintained.

To overcome 365 feet of fall, we may assume 36 dams, overcoming a lift of 10.14 feet each, including the fall of the canal. The length of each canal will then average 8.11 miles, with a fall of 1.25 feet per mile. The top of the dam will necessarily be 16.14 feet above the bottom of the canal at the point of entrance into the pool below. Allowing six inches of fall to the mile for the natural fall of the bed of the river, the height of each dam must be about twelve feet, the cost of which will probably be about \$70,000 for each dam. The canal embankment, extending from the dam to its entrance into the next pool, must at the dam be above the head of the stream fully nineteen feet, allowing seven feet for guard until the water in the floods shall give sufficient depth for boats to pass safely and without difficulty each way. At the foot of the canal, the embankment may be only about seven feet, or one foot above the surface of the lower pool. The average depth of the embankment will then be thirteen feet, without any allowance for extra depth where there may be deep water in the bed of the stream. In order to resist ice, drift-wood, &c., upon the river side, the slope should be at least two feet base to one foot of perpendicular rise. Upon the canal side I assume one and a half feet base to one of rise as sufficient. Allowing seven feet for the top width of the embankment, the average width would be 29½ feet.

The amount of embankment contained in one mile would be 75,631 cubic yards, which at present times would probably cost 40 cents per cubic yard. Mr. Haupt proposes to cover this embankment with riprap. This probably would not be less than one and one-half feet thick, and will amount to 17,453 cubic yards per mile. As this would be of stone, similar to crib-filling, estimated in my plan of chute at \$1 50 per cubic yard, at this price the riprap would cost for each mile \$26,179 50. A puddle trench will be required under the center of the embankment, say fifteen feet wide and two feet deep, or sufficient to remove all loose and porous material, in order to form a water-tight foundation for the embankment upon the river bed. The excavation of this trench will amount to 5,866 cubic yards, and will probably be worth 75 cents per cubic yard. It is probable there may be gravel bars above the plane of the bottom line of the cross section of the canal and jutting points of the shore line which will require to be excavated, and in some instances embankment bars in deep places, raising the bottom to a regular plane in order to insure a uniform depth and flow of the water in the canal. This excavation and embankment will probably not be less than 50,000 cubic yards per mile, which perhaps may not cost more than 25 cents per cubic yard. Assuming the foregoing hypotheses to be correct, one mile of canal will cost \$73,331 40, and 292 miles \$21,412,768 80. Thirty-six dams, estimated to cost \$70,000 each, will cost in the aggregate \$2,520,000. Adding 10 per cent. for contingencies, the total cost of the Ohio River improvement (exclusive of the

falls at Louisville and the necessary reservoirs) upon this plan will be \$26,326,045 68.

The extra water supply necessary to keep up this kind of navigation is, however, an important consideration, and cannot be lightly passed over. Upon the basis that the natural flow of the Ohio in low water is 100,000 cubic feet per minute, to maintain a 5-foot navigation will require 84,200 cubic feet per minute for an indefinite period of time. If we assume sixty days' duration of this period, the requisite reservoir capacity will be 7,274,880,000 cubic feet. To keep up a 6-foot navigation, a further supply will be required per minute of 63,907 cubic feet. The time for which this additional water would be needed would in dry weather probably not be less than ninety days, or a further reservoir capacity of 8,282,347,200 cubic feet. It would require about 12,000 acres of land to be covered upon an average nearly thirty feet deep to retain the water for a 6-foot navigation. I consider it useless to speculate as to the cost of these reservoirs. It is reasonable to suppose that good sites may be found for a limited number of reservoirs, but they may be where land would be very costly, while in other places the small amount of water which may be retained might not justify the building of a dam and other works for such meagre results. The plan of slack-water navigation for the Allegheny and the Monongahela, with retaining pools above a given depth for navigation, will undoubtedly be very expensive. If we suppose these pools to average 1,000 feet wide, 7 feet deep, 200 miles in extent, the water will be only sufficient to maintain a five-foot stage in the canal. If we make fifty dams, with a lift for each lock of eight feet, we will only overcome the fall in those streams, which is on an average nearly two feet to each mile. The additional pool of seven feet to be drawn off would make each lock equivalent to fifteen feet, or a total lockage construction equal to 750 feet. If these locks are built 60 feet wide and 300 feet between the gates, and should the dams average 900 feet wide, the quantity of material required would be fully double the amount used in the locks and dams upon the Green and Barren River navigation, in Kentucky. Adding therefore, as before, to the cost of that improvement fifty per cent. to cover present prices, the cost of dams and locks upon the Allegheny and Monongahela would now be \$30,000 per foot-lift, and for 750 feet \$22,500,000. Ten millions and five hundred thousand dollars of this sum would probably be applicable to the Ohio River navigation. It is therefore highly probable that on this plan reservoirs will be found much the cheapest for feeding the canal with water during the low-water stage of the Ohio River.

I cannot dismiss this subject without expressing my high appreciation of the skill and engineering talent displayed by Mr. Haupt in projecting his plan for the improvement of the Ohio River. Although costly, as all radical improvements must be, it nevertheless merits full and impartial consideration. The improvement, upon this plan, would certainly be a grand achievement, and I think far superior to locks as a means of overcoming the fall in such a river as the Ohio, where expense is not an object of paramount importance.

QUESTION 12.—*Any general or special views that may occur to you as likely to be of practical utility.*

In answer to this question, it may not be improper for me to advert to my experience as a civil engineer in the construction of slack-water navigation, and more especially to that relating to such as were made for steamboat navigation.

I was appointed chief engineer for the improvement of Green and Barren Rivers, in Kentucky, in 1835. Previous to my appointment, General Abner Lacock, of the State of Pennsylvania, in 1833, had, by solicitation of the Green and Barren River commissioners, made examinations and surveys of a portion of Green River, in order to advise with and recommend such plan of improvement as he might consider best. He did not hesitate, but boldly recommended locks and dams for steamboats, as the best means to accomplish the object and render navigable for steamers of moderate size this important river. This was the pioneer improvement of the kind in the United States. The examination made by and under direction of General Lacock resulted in placing under contract two locks and dams, in 1834, which would slack-water and render navigable one hundred miles of Green River. Mr. William B. Foster, jr., of this State, (Pennsylvania,) and formerly resident engineer under my charge in the construction of a portion of the Pennsylvania Canal, was appointed chief engineer. But owing to bad health he resigned early in 1835, and by solicitation and advice of my friend General Lacock, I was appointed and accepted the position of chief engineer. At that time little work had been done. The legislature of the State appropriated money sparingly. The works to be built were inferior, in their specified size and quality, to suit the demands of the age and the wants of the community interested in this noble river. I succeeded in getting the commissioners to increase the length of the locks from 145 to 160 feet between the gates. The width of the locks was fixed at 36 feet. Lock and dam No. 1, located near the mouth of Green River, was abandoned by the contractor after I took charge of the work. I was enabled, therefore, to require an improvement of the quality in the execution of this work by the new contractor. By direction of the board, I made further examinations and surveys, selected two more sites for locks and dams on Green River, and one on Big Barren, thus completing the location of five locks and dams for a continuous slack-water navigation of 175 miles from the mouth of Green River to Bowling Green on Big Barren, and overcoming a lockage of 78 feet. The lifts of the locks varied from $14\frac{1}{2}$ feet to 16 feet 10 inches, averaging $15\frac{1}{2}$ feet. The minimum depth of water was fixed at 6 feet. The heights of the dams would therefore be from $20\frac{1}{2}$ to 22 feet 10 inches above the bottom plane, or lower miter sill of its adjoining lock. The locks were built of cut sandstone laid in Louisville water lime, with the exception of lock No. 2, which was laid in common lime. The dams were of the ordinary crib-work with stone abutments. This brief history and outline of the plan of the "Green and Barren River navigation," is given to enable me to explain the effects produced by these dams on the height of floods upon those rivers. The opinion formed by some that the dams would cause a great increase, in times of high water, in the elevation of the floods, has signally failed to be realized. I freely admit that I have gained much in my experience since I have seen the effect of the dams in this respect, on Green and Barren Rivers. Observation and reflection have enabled me to arrive at an approximate calculation of these effects, where the average cross section and fall of a stream is known, together with the height of a dam and the length of the discharging weir.

The ascent in Green River, from its mouth to the mouth of Big Barren, was 48 feet, and the distance 145 miles; from the mouth of Big Barren to Bowling Green, on that stream, one foot per mile, or 30 feet, and 30 miles in distance. The average fall in Green River was therefore nearly four inches per mile. The average width of Green River, at

about 20 feet elevation above the usual bed of the stream, was about 300 feet. The banks were very steep; generally we may note them at an angle of 45° . At bottom, therefore, the stream would be 260 feet wide. At the shoals, the stream was generally much wider. These shoals were generally a rock bottom, having falls within a limited distance of from a few inches up to eight feet. Between these shoals the water varied in depth up to sixty feet, and was said to have been sounded and found to average thirty feet from the mouth of Green River to the mouth of Big Barren. Big Barren, from its mouth to Bowling Green, was shallow in low water, its bed the whole distance being gravel. The stream on this account was nearly as wide as Green River, the current being more rapid, the fall greater. The dams in Green River were generally built upon a rock bottom, sometimes the base rising above the true plane of the river bed. The heights of the dams are, however, calculated from this river bed, the natural fall at each shoal being included in the height to the base of the dam. The weir of dam No. 1, near the mouth of Green river, was 500 feet; of dam No. 2, 680 feet, and the other two dams about 300 feet each. At the two lower dams, the natural fall at the shoals was very considerable, reaching eight feet at No. 2. This accounts for the great increase in the width of the river at these points. This increase of width in rivers at any considerable falls, is common to all rivers where the shores are liable to wash by the increased action of the current. A very marked case occurs upon the Ohio River at Louisville.

Before the dams were built, the floods upon Green River had reached an elevation of near 50 feet. On Big Barren, away from the influence of the Green River waters, the floods had attained a height of 40 feet.

The marks of these floods were observable on the trees upon the bottom lands of these streams. When I left Kentucky, about thirteen years ago, the dams had been built about twelve years; during that time no flood had quite attained the height of those marks, yet these streams above the influence of these dams, and the other tributaries, were as high as they had been formerly. The difference may be accounted for by the fact that large quantities of timber and brush had been removed from the banks, allowing a more free course for the flow of the water, fully offsetting the obstructions to its passage caused by the dams, proving that they did not cause any serious addition to the height of the flood, although these dams were much higher than those proposed for the Ohio River improvement.

The height and length of these dams being known, together with the width and fall of the stream, I now proceed to draw from these data, and from other data, and from other practical observations, the rules and calculations enabling us to determine very closely the true effects produced by these dams.

I will here compare and calculate, from the data heretofore stated, dams Nos. 2 and 3. The first, $20\frac{1}{2}$ feet high, 680 feet long; the other, 22 feet 10 inches high, and only 300 feet long. These are extreme cases, and I think will elucidate the subject clearly.

The guard or extra height of wall at lock No. 2 was less than 8 feet, while at No. 3 it was 10 feet; yet at the latter this height was not enough, and really should not have been less than $12\frac{1}{2}$ feet, while $6\frac{1}{2}$ feet would have been sufficient for No. 2. At No. 2, the length of the weir being but 300 feet, we must add to the necessary velocity 10 per cent. to cover the contraction of the fluid vein. At 33 feet, or about the height of the guard walls of the lock, the cross section of the stream would be 9,669 feet; the dam would occupy 6,229 feet of said

cross section, leaving 3,440 feet. The velocity of the stream in its natural channel 33 feet high, according to Eytelwein's rule, would be 3.85 feet per second. In order to pass this water through this contracted space over the dam, the velocity of the current must be accelerated to 12.21 feet per second, or an increase of 8.36 feet, to which should be added ten per cent., making the necessary increase 9.20 feet. This would require an extra head of 16 inches, which was found too much. For a 35-foot rise the velocity in the natural stream would be 3.93 feet, the cross section of the stream would be 10,325 feet, the cross section over the dam 3,672 feet. The accelerated velocity would be 11.05 feet, the necessary increase, with ten per cent. allowance, would be 7.84 feet, requiring a rise of $11\frac{1}{2}$ inches. A guard wall $12\frac{1}{2}$ feet high would not be too great, as experience demonstrated. It must be recollected that in falls of this kind the slope is gradual and extends over several hundred feet. There is no difficulty, therefore, in steamers ascending, with a reasonable head of steam, up a fall of one foot, or even more, over a dam.

At dam No. 2 the river is double the average width, with an allowance of ten per cent., which will cover the contraction of the fluid vein. The stream at 27 feet high would have a cross section of 7,749 feet. The cross section of the over-fall of the dam, $6\frac{1}{2}$ feet by 680 feet, would be 4,260, deducting ten per cent., and there will be 3,734 feet through which to pass the water. The velocity at 27 feet would be 3.48 feet per second, the accelerated velocity 7.24 feet. The rise required to give this accelerated velocity would be but $2\frac{3}{4}$ inches, showing that $6\frac{1}{2}$ feet guard wall would have been amply sufficient. It will, by extending the calculation, show that at this fall a dam with a freshet rise of 36 feet ceases to have any effect whatever upon the floods. The whole comparison is important, showing the necessity of placing dams where the weir can be made considerably longer than the average width of the stream. Nature, as a general thing, makes provision for this increase.

The falls of the Ohio at Louisville amount to 26 feet in extreme low water. The average fall of the river from Cincinnati to the foot of the falls is 6 inches per mile. The length from the foot to the head of the falls is 3 miles; the top or head of the falls is therefore $24\frac{1}{2}$ feet above the plane or base line. If the river at the head of the falls is twice its average width, a rise of $24\frac{1}{2}$ feet will bring the surface line parallel with the base, and the cross section of the water-way will be the same at the head of the falls as the average cross section of the stream. Hence a rise of $24\frac{1}{2}$ feet would be equivalent to a rise of 49 feet at Cincinnati and below the falls.

We are compelled, however, to build dams where no such advantages can be taken. I will assume, however, that the dams can be located where there is some increase over the average width of the stream. In order to be clear, I will assume that this increase is sufficient to overcome any contraction of the fluid vein in its accelerated velocity over the dam, which would probably be about 10 per cent. of weir or water-way over the comb. Assuming the Ohio River to average a fall of 6 inches per mile for a considerable distance, and the average width of the stream on its average bed to be 1,000 feet, the banks having an average slope of 2 feet base to 1 of perpendicular rise, I propose to calculate the effects of dams 13 feet high under these assumed circumstances: A flood of 21 feet in the natural stream would, by Eytelwein's rule, give a velocity of 4.01 feet per second. The cross section of the stream would be 21 to 8. The accelerated velocity over the dam must be 10.526 feet per second; the natural velocity be-

ing 4.01 feet, the increase must be 6.51 feet per second. This will require a head of 8 inches, which will be the effect of the dam at this stage of the water. Guard walls and abutments will require to be about 8 feet above the dam, under these circumstances, to be safe. A fall of 1 foot per mile, the cross section of the stream and the length of the dam in other respects being the same, the velocity will be increased in the stream to 5.95 feet per second. A flood of 23 feet, the increase or accelerated velocity would be as 23 to 10, or 13.685 feet per second, causing an increase of 7.635, or an elevation of 11 inches above the dam. Guard walls 10 feet above the dam would be necessary, as here shown, in order to equalize the fall below 1 foot. If we suppose 40 feet to be the extreme rise of a stream in its natural flow, having a fall of 1 foot per mile, the effect of the dam would be trifling. The velocity per second by the natural flow would be 7.79 feet per second, an increase of this velocity of 31 per cent. would be sufficient, or 2.42 feet, which would correspond to an increased elevation of only $1\frac{1}{8}$ inches. It would be easy to show that for a fall of 6 inches per mile the increased action of dams would be less. The fear, however, of unduly extending this communication forbids further enlargement upon this subject. I have based these calculations upon what I conceive to be observed facts; strict accuracy cannot be attained unless every fact is mathematically known which in any way affects the result.

Practically entire accuracy is not important. Every work should be so built as to be safe beyond theoretical deductions when any evil might result from a contrary course.

In my desire to be brief, if I have not made plain my answers to your questions, I trust and hope you will excuse me. I shall truly answer any further questions you may ask, and I hope when I have not made myself understood you will not hesitate to call upon me for such additional explanation as you may think necessary to a clear understanding of this very important subject.

Heretofore I have not given a full summary of the cost of improving the Ohio River from Pittsburg to its mouth, upon the various plans as herein set forth. In each case I do not include the falls at Louisville, which are already in process of being improved for the largest class of steamboats.

Without including the falls at Louisville, the fall from Pittsburg to the mouth of the river is, say, 400 feet.

Cost of improving the same with a channel 100 feet wide, and a minimum depth of 6 feet: with Livermore's improved chute in connection with dams, 400 feet, at \$42,764 35 per foot, equals \$17,105,740. Locks and dams: one lock to be 80 feet wide, and 400 feet between gates; cost of each foot of lock and dam, \$45,000; for 400 feet, \$18,000,000.

If we add another lock, 60 feet wide and 300 feet between the gates, the whole cost will be for each foot \$53,000, and for 400 feet, \$21,200,000.

The cost of the entire work upon the plan of Mr. Haupt, exclusive of reservoirs, (which cannot now be estimated,) will be, agreeably to my calculations, \$65,815 11 per foot, or, for 400 feet, \$26,326,045 68.

All of which is respectfully submitted.

ALONZO LIVERMORE,
Civil Engineer.

W. MILNOR ROBERTS, Esq.,
Superintending Engineer Ohio River Improvement.

BRUNOT'S HYDRAULIC GATES FOR CHUTES IN DAMS OR LOCKS.

Reference has been made in former reports to the plan of moveable hydraulic gates for chutes and locks, designed by F. R. Brunot, esq. A suggestion was made in a special report to the Department, dated May 2, 1868, to have this plan tested on a sufficient scale to settle the question of its utility for cases like the Ohio River, and permission was obtained from the Monongahela Navigation Company to test it on one of their dams, but owing to some technical difficulty respecting the appropriation of money for that purpose, authority for its construction has not been granted. It is possible that this plan may work advantageously on a large scale in the chutes of the low dams proposed in connection with the slack-water navigation for the Upper Ohio. The plan is certainly worthy of careful examination in connection with any system of dams with moveable chutes, as well as for lock gates.

The annexed drawing and accompanying description will convey a general idea of this plan.

Description of Brunot's hydraulic gate.

A. Is a hollow gate, which may be of iron or of wood, or of wood and iron, made water-tight, hung on a strong horizontal shaft running the whole length of the gate or movable dam. When allowed to be filled with water it falls into the recess B, so that the top is level with the bottom of the chute. When the water is out, either by being drained out or pumped out, the gate rises, from its buoyancy and the water pressure under it, and remains as shown by the dotted line D D, so that its top is just level with the top of the rest of the dam, forming a dam.

C. Represents a pump near one end of the hollow gate in the abutment space, which may be used for pumping out the water when it will not admit of being drained out.

E. Represents small valves for draining and filling the hollow gate, and F valve for draining the recess.

G. A valve for admitting water with the pressure of the upper pool. All to be so arranged that the whole may be submerged without injury in a high flood. The movable dam or hollow gate works well in a model, and it is believed that it will be found advantageous on a larger scale in connection with the improvement of some of the rivers or portion of them now under the care of the Government. It can be of indefinite length, extending entirely across any width of sluice that may be deemed advisable. It may be self-acting, arranged so that when the river rises to a certain stage, it will flow into a pipe, E, and fill the gate, causing it to fall into the recess and thus allow the river to flow over it through the sluice, increasing the depth of navigation at the dam by the depth of the sluice, which in this case is proposed to be $3\frac{1}{2}$ feet; so that if there should be about 5 feet on the dam, there would be about $8\frac{1}{2}$ feet through the sluice.

This is supposed to be applied to a dam with a rise of 8 or 9 feet from pool to pool, in low water, so that when there should be 5 feet depth on the dam there would be a safe navigation of about $8\frac{1}{2}$ feet depth through the sluice.

When low water comes, and it is desired to save the water in the pool, the hollow gate is drained of its water by a valve in the bottom, or pumped out, when it immediately rises and acts as a dam, and so remains till filled again with water.

There are various details which will occur in the construction which cannot be satisfactorily described in advance.

CANAL.

Although no engineer has formally recommended a canal improvement, the subject can hardly be regarded as fully discussed without at least a brief reference to a ship canal along the shore as a substitute for any improvement of the river itself. In this case there need be no question respecting the supply of water, which could come either from the main river, or from near the mouth of its tributaries.

The cost would depend, of course, on the dimensions of the canal and locks. Allowing the locks to be double, and similar in area of chamber to those estimated for the slack-water, with eight-foot lifts instead of six-feet, there would be between Pittsburg and Louisville thirty-eight, which multiplied by \$200,000, the

Approximated estimated cost of one set with 8 feet lifts is.....	\$7, 600, 000
And extending approximately the canal work, including feeder dams, aqueducts, culverts, and bridges, not less than \$70,000 per mile on 598 miles, it would equal.....	41, 860, 000
	<hr/> 49, 460, 000
Add 10 per cent.....	4, 946, 000
	<hr/> 54, 406, 000
Total approximate estimate.....	54, 406, 000

Or \$90,980 per mile. The great cost of such a canal is a serious objection; but besides that, it would at all times be liable to breaks which would be disastrous to commerce, while the cost of maintaining such a large canal operation, and keeping it in repair, would be as great or greater than the cost of working and repairing slack-water navigation. The crossing of all the tributaries on one side or the other of the river would have to be made either by costly aqueducts, or by means of dams on the Ohio, or at the mouths of the tributaries, involving in each case an outlet lock and a guard lock. It would be earlier closed with ice, and remain closed longer than would the slack-water, and it would accommodate only one side of the river, which of itself may be regarded as fatal to the plan.

Recently the public mind in the West has been much excited in the discussion of plans for the construction of a ship canal between Pittsburg and the lakes, by the route of the Ohio River to Beaver, 27 miles, and thence by way of the Pennsylvania and Erie Canal to Erie, the canal to be enlarged to the dimensions of a ship canal.

In that connection it may hereafter be worthy of more particular examination before deciding the precise character of the improvement between Pittsburg and Beaver—whether canal or slack-water; but as part of the general permanent improvement of the Ohio River navigation, it is obvious that the canal would not answer the purpose.

It is not less obvious that the low-water navigation improvement hitherto adopted can never meet the requirements of a regular deep-water steamboat business, which can only be attained by the successful completion of one of the plans already presented in this report.

CHARACTERISTICS OF THE LOWER OHIO RIVER, AND PLANS FOR THE IMPROVEMENT OF ITS LOW-WATER NAVIGATION.

The falls of the Ohio River, at Louisville, Kentucky, 599 miles from Pittsburg, besides being considered the line which divides the "upper and lower" portions of the stream, on account of the very palpable difference in elevation of the water above and below, can also be considered as the point where the characteristics of the river change, and

from whence a somewhat different system for the improvement of low-water navigation may begin.

The noticeable feature, or difference, which at once becomes prominent after passing the falls, is the accumulations of sand in the channels, which presents a new phase of obstructions to be remedied in some way. It is true that there are sand deposits which occasionally give trouble to the navigation at numerous points in the river above the falls, as for instance at Manchester Island, where, at the upper end coming in, there is at low water six feet depth; boats drawing six feet have rubbed when there was fifteen feet in the river elsewhere. But usually in the Upper Ohio the channel has a gravel bottom, and keeps a more permanent position, the sand having some regularity in the mode it runs off, leaving the channel from year to year but little changed.

Below Louisville the bottoms are much wider, and the side streams coursing through them have but little current, excepting in times of freshets, when their sand accumulations are deposited in the Ohio, which also has a more sluggish current here than above. The Ohio is now much broader, and sweeps in longer and more regular bends, so that even when the main current is swift there are continual deposits of sand made off the points of the bends, which trail along with the eddies of the under water, and in this way make higher shore bars, and cover larger areas of the bottom. Frequently the whole bed of the river, where there is at low water a tolerably well-defined and deep channel, becomes filled with the sand, so that a cross section at high water will exhibit the same general depth of water everywhere. This is the case occasionally to such an extent that a flood whose surface is actually, say, 40 feet above the bottom of the usual low-water channel, will measure really only from 33 to 35 feet in depth to the sand, showing plainly a deposit of from 5 to 7 feet.

As elsewhere noticed at points on the river above, this sand likewise begins to cut away or run off as the distance between the surface and the sand decreases, with the falling of the river, bringing also local falls into action. The difficulty is that often the water has run off more rapidly than the sand, leaving temporary shoals, which occasion serious difficulties in the navigation.

The circumstance of the existence of light sand-bars under a rapidly running water surface, supports in some measure the results of experiments, made chiefly in gauging the flowage of the Mississippi river, showing that below a point where the maximum velocity is attained, which is relatively near the surface, the current rate decreases until, very near the bottom, it is so feeble or so much retarded by friction, and interrupted by lateral or bottom eddies, as to have but little if any effect in moving the sand. Instances have been adduced showing that floats arranged to index the current near the bottom have moved up stream, a curious freak sometimes exhibited near under bluffs or banks, or along the shore where the sides and bottoms are very irregular.

As the river falls, it is plain that the point of maximum velocity approaches the bottom, and the less the current above, or near the surface, the less the retarding influence of eddies below, until at low water there is no room at all for eddies, and the sand, coming in actual contact with the downward current, is finally removed.

It is evident that the character of this change must depend greatly upon the rate at which the river falls. According to theory, the slower the fall, the less sand will be remaining at the period when low-water navigation may be said to begin; and this appears to be really the case.

The trouble to navigation in the Lower Ohio River therefore begins, according to these circumstances, at various stages, say from what *ought* to be eight feet, in instances, usually to five feet depth, for freight boats drawing four feet; that is to say, a boat drawing four feet may find from one foot to three feet less water in the channel than is necessary to allow her free passage.

Before speaking of means which might be suggested for the removal of sand from the channels, it will be well to notice another prominent feature of the Lower Ohio, and that is the obstructions in the shape of trees, snags, wrecks, logs, &c. The extensive tributary streams, as well as some portions of the Ohio itself, flow through country which, as yet, has been but partially cleared. The forests here stand on alluvial soil, so that there is not the same firmness about the roots that might be expected from the great size of individual trees.

Every tree along the valley of the Lower Ohio which stands on ground not over 60 feet above low water, is naturally a prospective snag. If it blows down, or is cut down and left, it must inevitably eventually find its way into the river, whether it floats or not, where it will either float away, become a snag, or contribute to the drift pile.

The same may be said of the trees along the tributaries, according to the extent of their overflows.

Besides trees that come into the stream in this way, the river, even when within ordinary limits, is continually undermining portions of the banks, causing acres of bottom-land to cave in, bringing the trees, stumps, and brushwood into the river in a wholesale manner. Immense cottonwood, sycamore, pecan, cypress, and other trees are thus continually accumulating, and, as might be expected, usually settle most where the channel is otherwise impeded by sand.

A sand shoal itself usually causes no other mischief than delays, but when snags protrude themselves, they may, in addition, render a channel exceedingly dangerous, particularly so when the current is so slight as to make their presence unmarked by the usual "break."

These snags may come, as they usually do, with the first of the flood, and having once caught in the bottom, are finally packed down with the sand, as it deposits, deeper and deeper. They of course remain with the last of the sand, or as long as their foot-hold is secure; but what is worse, having in the mean time become thoroughly water-logged, they often remain as permanent fixtures.

Here we have extraneous material deposited with the sand, which is not governed by the laws which regulate its deposition and removal, as was explained above, but which rather, on the contrary, tends to complicate and retard the regular operation of those laws. Frequently a single snag or wreck, having lodged in this way, will, as the river falls, entirely change the course of the channel, which may otherwise be in a natural process of cutting through to some definite shape. One snag has been known to deflect the channel from one side of the river to the other, abruptly changing the course of the river for one thousand feet. It is from the very fact of the readiness of the channel to shift and maintain itself for the time in any one course, from a cause so apparently slight, that we might hope, from some cheap artificial means, to direct and control this natural operation from the beginning, and so secure a good, easy course for the passage of steamboats. It is, however, of paramount importance that we first remove the snags in, or in the vicinity of, the ordinary channel limits, as they, more than anything else, help to retard the free passage of the sand. It is worthy of note that *any* plan of improvement for the Lower Ohio which does not under-

take to overcome these difficulties, and in some way provide means for the passage downward of the immense sand deposit, may result in failure.

During a part of the season of 1868, we had one steamer, the *Petrolia*, with her two crane-boats, at work upon the removal of snags, &c., on the Lower Ohio. Captain D. M. Dryden, the United States inspector on board this steamer, in one of his reports, writing from Hurricane Island, says:

"There are one hundred snags in the river here, all with their ends in sight above water. They are deeply imbedded in the sand and mud.
* * * * The snags are all very heavy, and have to be cut up into pieces and taken to the bank, or, when convenient, dropped into deep holes out of the way. The average size of the snags is from 2½ to 5 feet through at the butt, and from 60 to 120 feet in length, and are generally tough wood, consisting principally of oak, sycamore, pecan, elm, and cottonwood. Some of them require two crane-boats to remove them."

Our present operations will, for the time being, greatly relieve the river from these dangerous obstructions; but still it must appear that to keep it perfectly clear all the time there must be constant attention paid to the matter. One snag catches others, then wrecks accumulate, and in this way, from want of a little attention in the first instance, the entire river may in the course of a few years become as dangerous to navigation as ever.

With a knowledge of these general characteristics of the river, we may more intelligently refer to some means which may be proposed to better its low-water navigation.

We will pre-suppose that wrecks and snags do not enter in to complicate the question in general, no matter how they may be occasionally referred to. There is no doubt of the sufficiency of water on the Lower Ohio to furnish a perennial low-water navigation of at least three feet, and enough for a *greatly* improved navigation at stages higher than that for heavy-draught freight boats. There is, in fact, no way of determining, in advance, how much improved depth it is possible to obtain, supposing we arrive at some method of controlling the action of the sand and quickening the course of the river in certain places.

DAMS AND DREDGING.

At first sight it may appear useless to erect low dams, which inevitably must be entirely covered annually with sand; and it would seem that dredging in such shifting material could at the best prove but a temporary relief. But if dams ever confine water to channel courses, or if dredging ever deepens them it can only be through their agency that we can work here.

At some points a dam or several dams alone may be all that is advisable, and at others, dredging, as the only means, may be safely employed to make an improvement of the navigation, but at the worst places the two must be combined. The dams may always be considered permanent; in fact we want them to act like a line of favorably-disposed snags, which will turn the water after the sand has washed off of them, and after their pools have also been freed of such sand deposits; but while in a few instances dredging alone may be of permanent benefit, it must in general be annually undertaken. In short, means must be provided to assist the natural process of "cutting," wherever or whenever the channel is choked up with sand. It may be once or twice annually at

some points that dredging may be necessary. One of the principal questions in connection with cost in any system of improvement of the Lower Ohio would appear, therefore, to be in connection with dredging. We believe we can make it apparent that this item will involve but a small annual outlay.

DAMS.

We are not altogether in the dark as to what is the effect of dams alone in the Lower Ohio, as the Government many years ago built a number of them, some being made of stone, and we believe a few were built of piles and brush. Dams in the Lower Ohio can be built of any kind of stone, and as they so quickly become consolidated with sand there is no difficulty in making them water-tight. This is one manifest advantage that they have over those built on the Upper Ohio, on rocky or coarse gravel bottoms. The principal difficulty encountered in their construction is to prevent their settling bodily into the sand. This, it might be suggested, can generally be remedied by placing them on broad brush foundations or intermixing brush with the stone. It is not probable after one year, or after a few floods have passed over them, that they will settle any further. The settling of the dam will not be the chief trouble. The annexed sketch represents the dams as built at French Island, one of the worst points in this region, and where it will early be necessary to make improvement. This instance will serve to illustrate more fully, in a particular manner, what we have endeavored to explain in a more general way above in describing the characteristics of the Lower Ohio.

The sketch exhibits only the ordinary features, or so much of the sand-bars as remain permanently attached to the island, and the position of the two dams designed to concentrate the water and aid in keeping the channel to one place. These dams pass into the river at a point where sand deposits are made, covering the whole width of the river occasionally to such an extent that as good water is found on top of the dams as in the channel. The dotted line represents the channel as it often takes immediately *over* the dam on the Kentucky side, and then back again to the Indiana shore. This is the peculiarity: here we have a dam or permanent reef of stone and sand, (dry at some places at a three-foot stage when the channel is between the two dams,) at least four feet higher than the ordinary bottom of the river, and yet that bottom so varies that at other periods the low-water channel passes over it, and a better depth is found on the obstruction than in the channel. This proves conclusively that the plane of the low-water surface varies by several feet in height. Of course there could be no considerable variation like this at one point without a considerable fall there, unless this difference in height were taken up at other points in part, so as to make the average plane nearly uniform or parallel to its surface of other years. From the fact that several feet of difference at like low-water stages, as regards depth and amount of water flowing, can thus exist without making material changes in the low-water profiles of the ripples, we can believe that the elevation of the low-water surface must extend a long way on the river to be so nicely distributed. If the river here falls four inches to the mile, and sand deposits are made four feet deep in the channel, raising low-water surface to that extent, it would back up twelve miles; but usually the shoals above and below have the same or a proportioned deposit, so that it cannot be accurately determined to what extent these deposits affect the rate of the current; the circumstance is peculiar and characteristic, and undoubtedly is worthy of

study. The following lines may serve to represent the surfaces of water at like stages with profiles differing from each other in this way :

Starting from point L. (Louisville) the dotted line represents the ordinary low-water surface and depth on bars to Cairo. The black line, starting from the same point or level and closing at the same datum, at C. (Cairo,) represents a divergence at points of four feet in height of low-water surface, and height of bars. Suppose now we have dams, as at French Island, built; for awhile they will assist very materially in holding up the water; they will answer so long as they are not overlaid with sand; but after the sand has deposited say a foot or more on top of them, of course deeper in the channel, so that everywhere the bottom is regularly covered, whatever shape the channel, takes as it cuts with the falling of the river may be irrespective of the position of these dams. Should it happen suddenly to cut out *over* the dam, there the channel will go, and be maintained as deep as the stone or other material of the dam will allow the cutting to continue. This instance and others might be adduced to show the insufficiency of dams alone in certain situations. It should be presumed, therefore, that these low dams cannot be made effective alone. It is hardly necessary in this place to speak further of dams alone, as all the peculiar circumstances with which they are surrounded can be easily imagined.

DREDGING.

Dredging is frequently resorted to for the improvement of navigable channels; but, as yet, no serious attempt has anywhere been made to operate on such extensive and annually-renewed deposits as are to be found in the Lower Ohio River. The quantity which should be removed must in some years amount to hundreds of thousands of cubic yards; and the machinery so far invented to work this out, and the price paid for removing it by the cubic yard would prove too expensive. We believe that some simple arrangement must be devised, some way in which the natural forces at work, as noticed elsewhere, should be concentrated upon the sand deposits at such times as the current idly passes over them, as at the stages just preceding the return to low-water navigation.

The sand comes in naturally and passes off naturally with the force of the current at certain stages. Why may we not, in a manner, saddle the sand upon this current at such times, as it does not now appear willing to bear its load.

In this place we would desire to say that we have reasoned from general principles so far, and with little design of noticing particular plans, which as yet must be prejudged favorably, as it were, before trial. But we believe we may be able to suggest such simple plans as will probably accomplish the desired object. And on the score of its simplicity and cheapness it may be worthy of immediate consideration, trial, approval or condemnation.

Gravel that appears necessary to move sand, and we believe even light gravel, from channels is to direct the force of the current upon the material. This is only applicable to rivers having the current continually going in one direction. At least from our observation this appears to be the natural process, and the assistance we may give nature in this way will be all that may be necessary to expedite matters. Whatever comes in the river by agencies working according to natural general laws may be overcome in the same way.

DESCRIPTION OF A PROPOSED MACHINE FOR EXCAVATING IN SAND
BARS ON THE LOWER OHIO RIVER.

We propose, by wheels and other simple manageable machinery, to arrest the current of the river on the surface, or between the surface and the bottom, and by deflecting it toward the bottom to let it expend some of its force upon the sand or other material easily removed in this way. It is not proposed to measure the amount of material removed, further than by its effect upon changing the channel; the work to proceed at any one point until assurance is given that a course is sufficiently well started in the proper line of channel, so that it will continue without further aid to cut out as the river falls, or until the dams are uncovered, when for the time of that low-water period it will be impossible for the channel to take any other shape. The whole thing is simple enough, and only requires faith in nature, while at the same time, fortunately, the proposed appliance involves little skill, and can be worked and adjusted to suit different places, easily and economically.

This method of working sand is reducing the cost to "time" of unskilled labor; removing a bar in so many days, with so many men employed.

It may be remarked here that it is not always the amount of material removed that will perfect a channel; anything that merely *starts* the cutting process does what may be equivalent to a much larger amount of work at a more unfavorable period for the purpose.

The accompanying sketches will serve to show in general the simple character of the machinery which, it is believed, will successfully operate in the river chiefly by the power of the current, in removing sand deposits.

Reference has heretofore been made to these views and plans, in a letter to the superintending engineer Ohio River improvement, a year ago, when the subject of dredging machines and channel excavators was before a board of United States engineers assembled at Pittsburg; also some views in this connection in a report to the superintending engineer dated December 7, 1867, in relation to the shifting of bars in the Upper Ohio, and the effect of steamboats passing over bars, all of which may be referred to as preliminary to the subject in hand.

No very elaborate explanations seemed to be required in studying these plans. The first represents the plan, two boats 130 by 18 feet lashed together, with the wheel and drop-scrapers; there is shown the position of small stationary steam-engines, and combination capstans, to be worked by hand or steam, with which to drag the boats upwards over shoals, or to work the mounted "following scrapers" back and forth as the sand is driven downwards.

The second or side elevation represents the mode the wheel and drop-scrapers can be raised and lowered to suit different depths of water.

The third side elevation of mounted scrapers, to be either attached to the main scraper, or pulled along by tow-boats. When but a moderate quantity of scraping seems to be necessary, a section of these might be advantageously employed on "detached service." The principle, it is apparent, is the same in all of the methods, leaving everything to the action of the water.

In the wheel, however, there is an increase of power gained by the momentum, which may often be necessary in working hard clay or gravel. The force of the current striking against such a broad surface as may be presented in the buckets, (which may be varied in width on the wheel,) it is expected will overcome any peculiar obstacle a plough-

point here and there may come in contact with. It is apparent that steam power can be applied to these wheels, exhibiting the precise effect of an increase in the rate of the current, (of course the boat would have to be anchored and regulated from both ends to hold her position in the latter case, or else additional drop-boards can be placed with good effect in retarding the boat, and at the same time act beneficially in stirring up the sand between the two flat-boats.) The steering oars and capstan are all that is necessary to hold the machine in any position.

The isometric view* will probably give a clear explanation of the whole. Some calculations that may be of service are presented, from which approximate estimates of the work of this machine can be determined.

The wheels are 16 feet in diameter, and will turn with the current as follows :

Current, miles per hour.	Revolutions per hour.	Revolutions per minute.
1	136	$2\frac{1}{16}$
$1\frac{1}{2}$	196.5	$3\frac{1}{4}$
2	262	$4\frac{1}{2}$
$2\frac{1}{2}$	327.5	$5\frac{1}{2}$
3	393	$6\frac{1}{2}$
$3\frac{1}{2}$	458.5	$7\frac{3}{8}$
4	524	$8\frac{2}{3}$
$4\frac{1}{2}$	589.5	$9\frac{5}{7}$
5	655	11

The United States steamer *Fidivute*, with a wheel 14 feet in diameter, length of bucket 14 feet and width of bucket 14 inches, working 30 revolutions per minute, represents 55 horse-power, or the actual development of a 55 horse-power engine, minus friction. Say the actual force exerted on the water is equivalent to 36 horse-power. Now, beginning with the wheels stationary, there must be a regular increase of power exerted for each additional revolution per minute. This would make, at 15 revolutions per minute, 18 horse-power; at $7\frac{1}{2}$ revolutions per minute, 9 horse-power, and so on. The wheel of this machine is 16 feet in diameter, 23 feet long, and buckets $2\frac{1}{2}$ feet wide, (or more, according to circumstances,) being $3\frac{1}{2}$ times as large, or presenting $3\frac{1}{2}$ times the surface of the *Fidivute* wheel. From our table, at a $3\frac{1}{2}$ mile per hour current, the power exerted by the water on the wheels of this machine would represent 30 horse-power, or deducting one-third for friction of journals, (though that seems large,) 20 horse-power.

At all events it must appear that there is a considerable force exerted, and that its economical application can be made to remove sand.

NOTES.

The drop-scrapers are to be provided with means to allow the escape of water through them at such times when the force of the current would have a tendency to buoy them up too much. This is shown in the first plan.

The anchor line must pass out ahead, reeved through a block to be held by iron supports from the bow of the boats, as represented.

* Omitted.

The same arrangement at the stern must be made, so as to pass the wire or other line to the guide wheel of the mounted trucks to secure their proper management.

A principal advantage of this machine over Noble's channeler is that all the material is thrown downwards in the line of the current, whereas that machine threw it out at the side, leaving ridges along the channel; moreover this machine will work any width of channel by merely the steering operation.

THOMAS P. ROBERTS,

Assistant United States Civil Engineer.

W. MILNOR ROBERTS,

United States Civil Engineer,

In charge Ohio River Improvement.

PITTSBURG, PA., February 25, 1869.

THE LOW-WATER NAVIGATION OF THE OHIO, AND PLANS FOR AMELIORATING ITS NATURAL CONDITION.

The subjoined description of the Ohio River is more especially designed to illustrate not only its general features in regard to channels, bars, currents, &c., in their natural condition, but also to exhibit the probable extent and general character of the work designed for its low-water improvement.

A plan for a low-water improvement of the Ohio may be defined as a method to widen, deepen, or straighten its natural channels at the shoals and ripples, by means of the removal of rocks and boulders, gravel excavation, or the erection of wing-dams and landmarks. Incidentally and very important in the thorough improvement of the low-water channels of the Ohio is the removal of obstructions caused by wrecks, snags, roots, logs, drift-piles, &c.

It would appear to most persons not acquainted with the nature of the Ohio, its width, its great range in height from low to high or flood stages, the nature of its bottoms and banks, and the varied and extensive commerce it accommodates, that a low-water improvement such as above defined, at least for single light-draught boats, could easily be made and maintained by confining it in the middle to canal dimensions, &c.

There is no doubt that were the navigation conducted as formerly, in single boats instead of the great fleets of barges which have now to be accommodated, the conditions of depth and width sufficient for a permanent navigation could be more easily maintained; but for the passage of the heavy business now done, an available space of at least six hundred feet should generally be left unobstructed by wing-dams; and as many shoals and bad points are in such situations that wing-dams cannot safely be resorted to, it follows that there is a restriction placed on this mode of improving the river. There is, therefore, not now as much opportunity to develop the system of low-water improvement as was enjoyed by Captain Sanders in 1838, when he was building dams and removing snags, &c., in the Ohio.

Still, however, much has been and more can yet be done. In the estimates presented for wing-dams, care has been taken to suggest no improvement of places which would not be suitable to the character of the business now done. At the same time the improvement of no single points is urged further than the limit of its availability in a general system for long distances. It will appear, in considering the nature and

succession of the pools and ripples of the Ohio, that though a number of bad points may be improved by the addition of a foot or more to their available depth, it will be of no general benefit to navigation as long as worse points above or below prevent boats reaching them. This is so self-evident that it would appear to need no mention; but the fact is important to recollect by those who urge the improvement of the river, and by Congress when making appropriations; it is also evident from this that were the entire river improved, the destruction of a dam at one or two points would affect the utility of the entire series of works. These are the general considerations to be taken into account by the engineer in considering the plan of low-water improvements.

In Major Sanders's reports upon plans and operations for the improvement of low-water navigation, and in Major Hughes's and Mr. Fuller's report and notes, made some years after 1844, the date terminating Major Sanders's work on the river, will be found a fund of practical and scientific information in connection with the Ohio River. Mr. Fuller's and Major Hughes's almost constant residence in boats on the Ohio, for several years, enabled them to witness nearly all of its varied phenomena, in its changes of channels, cavings of banks, &c., and other peculiarities attending the rise and fall of the water, with its increasing and diminishing rates of current, formation of bars, and the action of ice, drift, &c.

In nearly every particular, later observation and advanced knowledge in the practice of river improvement tend to confirm the statements made, and the opinions these gentlemen expressed.

In justice to these engineers, who were among the first engaged in this country upon river improvements, it will not be amiss to quote from their published reports matter of general interest and particularly desirable to lay before those who may have the Ohio River in charge hereafter. The following description, from Major Hughes's report, gives a truthful picture of the characteristics of the river, as far as it goes. His statements of the probable effects of extensive dredging at bars and shoals are particularly valuable, as they accord with the theories and practical deductions of many engineer officers engaged in similar operations since:

The general character of the Ohio, above the falls, is singularly uniform, and it may be properly described as a regular succession of alternate short ripples and long pools, produced by the intervention of bars, usually found at the heads of islands or rocky ledges. The current in the pools is very gentle and almost sluggish; in low water over the ripples it is at all times more or less rapid, depending on the height of water, the fall and the breadth of the chute, but it flows very nearly at a uniform velocity over pools and ripples in times of floods, and approximates to uniformity as the river rises during freshets. In partially removing the bars, either by scraping or by the erosive action of the water when concentrated into a single channel, care must be taken not to permit the excavation to extend below a plane (beginning, say, on the bar at Pittsburg, as a point of reference, and passing through all the shoalest bars on the river) nearly parallel to that which the river assumes at high water. The effect of lowering the bars beyond a certain line would be to decrease the depth of water in the pools above, and to add to the perpendicular fall of the adjacent ripples, thus accelerating their velocities, and decreasing the depth of water over them; this would of course aggravate rather than diminish evils.

It may be stated as a general rule, to which there are but few exceptions, that when the volume of water is undivided the navigation is not impeded, as the bars usually occur at or near the heads of islands which separate the river into different channels; and reasoning from this state of things, it has been frequently suggested that if the bars were removed the difficulties would no longer exist, losing sight of the fact that to these very bars is due the prolonged season of navigation, and that without them, for considerable parts of each season, there would probably be no navigation. They are analogous in their action to dams and sluices, and if removed the greater portion of the water would rapidly run off, leaving not enough in the channel for any practical purposes.

They may unquestionably be partially removed, in many cases, with beneficial results, but the experiment should be watched with extreme care, and the extent to which this deepening may be carried must be limited to the conditions already described.

The river is of nearly a uniform breadth, gradually widening in proportion to the accession of its tributaries; but as it does not spread out into lakes acting as reservoirs, its waters are rapidly discharged, and when the rains cease to fall its supplies are speedily exhausted. The removal of the bars would, of course, under such circumstances, rapidly diminish the pools immediately above them.

None of the reports by these gentlemen refer particularly to the difficulties of the Lower Ohio River, where the changeable sand-bars present such serious obstacles to navigation. A paper prepared by one of my assistants, to be found in another part of this report, gives some interesting views upon the features and characteristics of the river below Louisville.

WRECKS AND SNAGS.

In regard to snags, Major Hughes reports that they were most troublesome, at the time he wrote, on the Upper Ohio, between Parkersburg and Cincinnati. He says:

The removal of snags in the Ohio is attended with more expense than in the Mississippi, owing to the difficulty of disposing of the roots, which, in the Mississippi, are thrown into deep pools and are soon covered over by the mud deposits. On the Ohio they have been compelled to carry them on shore and burst them to pieces with gunpowder.

He reports that—

From the commencement of the work, in 1836, up to the 30th of September, 1837, there had been 3,303 obstructions of various kinds removed from the channel of the river. Of the obstructions removed in 1837, 1,040 were snags, trees, and roots. The steam and machine snag-boats were continued at work during the month of October of the same year, but I am not informed with what success. At medium high water the snags (by which term I mean trees or any portion of them) are perhaps more dangerous than at any other stages, as at high water vessels pass harmlessly over them, and at low water only boats of light draught, running usually in daylight, and at low velocities, are employed, and they are compelled to keep the low-water channel, which is generally of limited breadth. Snags in the channel of medium high water are dangerous impediments, rendering the navigation extremely hazardous. In the low-water channel they are less dangerous, but amount to positive obstructions, as they fill up the foot of the chutes.

It is proper here to remark, in connection with the above observations, that at different stages of the water the currents take different directions, and boats in descending avail themselves of the force of the current as much as possible, keeping nearly the middle of the channel for the time being; and in ascending they avoid the currents, taking the eddies along the shore, when practicable, and the same result follows. It will thus be apparent that our attention to the removal of snags must not be limited to those in the low-water channel, (important as that undoubtedly is,) but that all in the bed of the river should be extracted.

A new element in the way of obstructions to be removed consists of wrecks, principally of coal-boats and barges. The work, more particularly upon the removal of snags, since I have had charge of the river, is generally complete as far down as Louisville. During 1867, one steamer with its crane-boats and flats was employed, removing during the season many snags and wrecks between Pittsburg and Portsmouth, three hundred and fifty-three and a half miles. In 1868, three steamers, each with two crane-boats and four flats, were engaged part of the season, respectively, between Pittsburg and Portsmouth, where one hundred and fifty snags and fifteen wrecks were removed; between Cincinnati and Louisville, where seven wrecks and twenty-four snags were removed; and between Louisville and Cairo, where ninety-nine snags were removed.

The season of 1868 was not favorable for these operations. During 1869 two steamers, each with one crane-boat and two flats, were employed; one between Pittsburg and Cincinnati removed 48 snags and 12 wrecks;

the other between Cincinnati and Louisville removed 155 snags and 2 wrecks, besides 150 cubic yards of dangerous rocks. The United States snag and wrecking steamer I. I. Abert, and the United States snag and dredging steamer Octavia, worked during the fall of 1869 between Hurricane Island and Cairo.

The two last-mentioned steamers were working under the appropriation for western river improvements, under the charge of Colonel J. N. Macomb, United States Engineer Corps. Probably no work done in improving the natural channels of the river returns so large a benefit to navigation, in proportion to its cost, as the removal of snags and wrecks.

BRIDGES.

The question of bridges across the Ohio, where there are piers confining the channel of the river to less than 500 feet in width between the piers, is at the present time exciting considerable discussion among navigators. Previous to 1862 there were no pier bridges across the Ohio River; the Wheeling suspension bridge being the only bridge structure crossing it at any point. It had one span of 1,020 feet, elevated for a length of about 300 feet over the channel, 95 feet above low water; the remaining portion of the roadway being inclined to the shore and island abutments. The question of height of bridges was then regarded as a serious matter, but since the introduction of hinged or telescopic chimneys on boats, river men have become reconciled to bridges of that height. The Cincinnati suspension bridge, with a span of 1,057 feet, was finished in 1866; it has also a height of 95 feet in its central portions above low water. As the water rises 15 feet higher in flood stages at Cincinnati than it does at Wheeling, and remains at higher stages for longer periods, it is obvious that the height of bridges, as we go down the river, is a more important matter for consideration. But at present no questions appear to be mooted concerning the height of these structures. The boats doing the heavy business, chiefly tow-boats, are lower and smaller than the packets were formerly, though representing more power, and can at nearly all times pass under these bridges.

In 1862 an act of Congress was passed fixing the channel span at 300 feet for any railroad or pier bridges. Under this authority the celebrated and magnificent iron bridge for the Pittsburg, Columbus and St. Louis Railroad was built by a company, across the Ohio at Steubenville. Scarcely was it finished, however, when wrecks of coal and other boats began to accumulate. It is apparent that piers only 300 feet apart are serious obstructions to the free navigation of the Ohio.

Since the construction of the Steubenville bridge in 1863 several hundred thousand dollars' worth of coal have been lost by the boats striking against its piers. During 1869 the piers of the Baltimore and Ohio railroad bridges at Bellaire and Parkersburg were partially completed, and those of the Louisville bridge were finished. The Bellaire bridge, like the Steubenville bridge, has but one channel span of 300 feet. The Parkersburg bridge has two channel spans, one of 300 feet and the other 330 feet. The Louisville bridge has two channel spans, one of 370 feet and one of 400 feet. Other bridges are proposed and spoken of at Ironton, Ohio; Guyandotte, Virginia; Cincinnati, Ohio; Paducah, Kentucky, and other points.

Frequent conventions have been held, and remonstrances made to Congress by river men, praying that the channel span for these structures should be fixed at 500 feet, though latterly a desire has been manifested to compromise with the railroad companies building the bridges

for 400-foot spans. When it is recollected that thirteen disasters, recorded in 1869, happening to tow-boats with fleets and single boats, foot up a loss of \$299,000, the consideration of this matter will commend itself to our legislators. It hardly comports with the object of this report to more than refer to these bridges, but I have felt it as an imperative duty, while in charge of the Ohio River improvement, to call the attention of the Government to the importance of the question. It rises prominently in connection with any improvement which may ever be attempted. No one can appreciate the necessity and usefulness of railroads more highly than myself, and I fully understand the advantages to them and to the country generally of crossing our navigable rivers by bridges, but I have for years been interested both in railroad progress and river improvements, so that I have strong ties in connection with both of these great interests. In my capacity, therefore, as an independent engineer, I am not risking much in averring that our rivers have, equally with railroads, a right to legal protection.

It is futile, in the face of the present engineer experience, to say that a span of 300 feet is the limit of safety for railroad bridges. The question is resolved altogether into a matter of cost, and it remains only to consider the relative value and importance of the river, and of the special railroad crossing it, to decide what the limit of span in bridges across the Ohio should be. In the summer of 1868 Major General G. K. Warren, United States Army, was called upon to examine into this matter, and after visiting the Steubenville bridge and other points he came to the conclusion, as expressed in his report to the Senate committee, that though the span at Steubenville, which is 300 feet over the main channel, was not enough for that point, owing to the proximity of the bridge to difficult bends, where boats are thrown out of the channel by shifting currents, that still there are points where much greater spans would not be required. These are considerations proper to be taken into account when authority is given for the construction of a bridge. It would appear, in conclusion, highly advisable to have such matters thoroughly studied by intelligent and capable engineers before definite decisions relating to the span of particular bridges are determined upon.

CHANGES IN THE CHARACTERISTICS OF THE RIVER.

Since the early days of steamboat navigation on the river there has been observed a great improvement of its condition at many points over what existed formerly, and at places where no work has ever been done. At many shoals and ripples where the bottom was formerly rough and covered with dangerous boulders, none are now to be found. These changes are believed to have been in part the beneficial result of the constant passage of steamers, disturbing with their wheels the bottom of the river, setting the boulders in motion, which have gradually by the force of the current been rolled downward into the deeper water of the pools below. The river at many points has in this way alone been very materially improved during the last forty years, so that it now presents less unfavorable aspects than ever before.

The clearing of the bottom lands and adjacent country of timber, has had the effect of greatly diminishing the number of snags which come in with the flood, so that now when once thoroughly cleared of the present obstructions of this sort it will be much more likely than formerly to remain so for a longer period.

Clearing and cultivating the bottoms along the river had also the effect, however, of making the shores more subject to washing and caving

into the stream, and thus furnishing material for deposits. At some places the river has been widened in this way several hundred feet, causing more spread of water than formerly; but with the increasing value of these lands the owners are finding it to their interest to protect their banks by planting willows and cottonwoods, which not only break the force of the current against them but hold great quantities of drift and sediment, and save the banks.

There is reason to suppose that in this way the lost ground can be eventually reclaimed, the river somewhat narrowed, and the annual sand deposits greatly lessened in quantity. Many consecutive miles of the river are now protected, and on the whole river probably more than a third of both sides is now clothed with a growth of this sort. There still remain, however, long stretches of caving banks of this sort, some of which it might be advantageous at some time for the Government to undertake to protect with willows and picketing. Such points as the Ohio side along Blennerhassett's Island, and the shore above Letart's Island, Manchester Island, Augusta Bar, and Four-Mile Creek Bar, and many others, might be singled out. In thus aiding the workings of nature, the engineer will in return receive great assistance.

We in fact in this way will aid in restoring the river to its most advantageous regimen.

That great changes everywhere result in the physical world which are due to the natural effect of vegetable growth, is undoubtedly so well understood as to require no special illustrations in this place.

I would only desire to present the consideration of the subject more particularly as applicable to the improvement of the Ohio River, and in conclusion instance a case in point on the river where great and rather disastrous changes have resulted, it is said, by the accidental start of willow growth upon a former gravel tow-head which occurred at Louisville.

Forty years ago Kygar Island, at Louisville, above the falls about a mile, was a low gravel-bar, over which the water flowed freely at ordinary stages. The accidental deposit of a mass of drift upon it furnished a foothold for a natural willow growth which rapidly and firmly established the foundation of an island, growing in an increasing ratio with the continued deposit of drift that settled upon it. The current, which usually took over the former bar, was then at flood stages deflected with great force to the opposite shore, near the head of the Indiana chute, from whence it was reflected to the Kentucky side where it struck Corn Island, which was to all appearance a permanent point of arable land, fixed on a rock. Corn Island rapidly disappeared under the effect of the unusual current striking it obliquely. Aided by other forces set in motion, and in the falls, the current was again deflected with increased violence to the Illinois shore at Big Eddy, where it is said a considerable caving of the banks took place, increasing the indentation in the shore at that point. From Big Eddy the current was finally turned in the flood stages at another angle to the foot of the falls on the Kentucky side, with the effect of building up Sand Island, which ever since accumulates after every flood immense quantities of sand, very annoying to the navigation of Portland Bar, as it is discharged or unloaded into the current immediately above the canal outlet at the very time the water gets shoal. This indirect action of willows *forming* a bar could hardly have a parallel elsewhere on the river.

With these general remarks upon the natural features of the river, it is believed that the following description of the several points with regard to a low-water improvement will be more readily understood.

The surveys from which the distances were taken were completed under Major Sanders and Mr. Fuller in 1844, as far as Clipper Mills, two hundred and seventy-one miles below Pittsburg.

From Clipper Mills the surveys were resumed June, 1867, under my directions, and completed to the mouth of the river at Cairo, nine hundred and sixty-seven miles from Pittsburg, in November, 1868.

More special reference to the surveys, maps and profiles accompanying this report will be found elsewhere.

DESCRIPTION OF THE OHIO RIVER, SHOWING DISTANCES, LENGTHS OF POOLS, RIPPLES, FALLS, EXTENT AND CHARACTER OF BARS, AND PLANS AND ESTIMATES OF WORK PROPOSED AT VARIOUS POINTS FOR THE IMPROVEMENT OF THE LOW-WATER NAVIGATION ON THE ENTIRE RIVER, NINE HUNDRED AND SIXTY-SEVEN MILES.

Remarks.

Brunot's Island, two miles from Pittsburg.—Both sides of Brunot's Island remain open for navigation. Dams have been proposed at the head to confine all the water to one side or the other, but as the chutes of this island are so intimately connected with the harbor of Pittsburg no work upon them has been done, excepting in 1844, when some stone was put across Duck chute, which, after a three-foot stage, drains a little water from the left into the right chute, through a pass across the lower end of the large bar and immediately above the island proper.

Left Chute or Rowley's Channel.—Formerly the left side of Brunot's Island was never run at low water, on account of dangerous rocks in the channel above and opposite Chartier's Creek, but during the fall of 1867 Captain John Rodgers, under contract with the Government, worked a month with a crane-boat and party, and removed a number of these rocks, making a safe low-water channel, with a foot better water than that afforded in Grass House Ripple, on the right side of the island. In addition to the removal of the rocks a contract for 1,000 cubic yards of dredging was entered into for straightening the new channel at Chartier's Creek, so as to make it available for boats with barges in tow.

During the season of 1869 the dredging machine worked at this place, removing, besides the amount of the contract, a considerable surplus available from other points. The low-water channel was considerably straightened. The fall at this ripple is too great, however, to hope for a thorough improvement by means of dredging alone. For single boats there is now afforded, however, a foot better water at low stages than existed formerly. The right channel of Brunot's Island is not now used at low water, since the improvement of the left side.

Right Chute or Glass House Ripple.—Thirty years ago Glass House Ripple was not accounted a bad place, but during this period it has become worse and worse, until lately it had become ten inches shoaler than the shoalest bars on the entire river below. The bottom, though composed of coarse gravel and boulders, has by the action of steamboat wheels, aided by the powerful current, been continually moving, throwing the shoal further and further down. It is not probable that dredging alone would improve this place, as the water already flows in a very narrow space, and dredging would only sink the surface at about the same rate it would the bottom, and besides would drain the pool up to the city at the expense of the shoal place coming in at the junction of the two rivers, Alleghany and Monongahela.

According to the gauging of Captain Sanders, in 1838, the quantity of water passing in low water was in Glass House Ripple 40,784 cubic

feet per minute, and in the left, or "Rowley's Channel," as it is now called, 58,880 cubic feet; total, 99,664 cubic feet—in round numbers, 100,000 cubic feet per minute. Velocity at that time (low water) was 2.21 miles per hour [at a $6\frac{1}{2}$ feet stage the current flows here at the rate of 7.1 miles per hour] in the right, and 2.11 miles an hour (low water) in the left. Captain Sanders made the length of Glass House Ripple 550 feet, and fall 2.25; descent, 21.10 feet per mile. Width of Glass House Channel, at that low stage, 137 feet across the surface of water; depth at the head, 17 inches.

In the left chute there is a fall of only 1.3 feet in the ripple in a distance of about 600 feet. The whole fall from Cork's Run, opposite the head of the island down to the foot of Brunot's Island, is 3.5 feet.

I have inquired into the merits of a number of plans proposed for a more radical improvement at this island, so that not only the low-water steamers, but the coal-boats can as readily pass these obstructions as others. A crib-dam, eight feet lift, with lock and chute below McKee's Rocks, would make both sides of the island available, and add several miles of good landings to the harbor of Pittsburg, which is greatly desired by the coal men. But without so great an expense, a riprap dam placed across the left chute, above Chartier's Creek, to turn all the water down Glass House up to an eight-foot stage, would appear to be the next best plan. Such a dam would require 9,000 cubic yards of stone.

Foot of Brunot's Island, three and a half miles from Pittsburg.—Good water, at all times, from foot of Brunot's Island to head of Horse Tail Ripple, (at head of Davis's Island,) say two miles.

Horse Tail Ripple, five and a half miles from Pittsburg.—A few loose rocks are sometimes struck opposite the head of the old mill-race dam. Dams were partly built at the head of Davis's Island, and between Davis's Island and Neville's Island; but an opening has since been made in the upper dam by the people, to make a small boat channel.

In 1838, 18 inches of water in main channel. Length, 1,280 feet; fall, 2.43 feet. Velocity, 2.11 miles an hour. It is called now, at extreme low water, two feet depth. The channel is straight along the old mill-race dam. [Shown on the chart.] There are a number of loose boulders, &c., in this channel, which could be removed to advantage. In my annual report for the year ending June, 1867, I have estimated that this work would cost \$500.

Good water from Horse Tail to Lowrie's Ripple, two miles. [This reach passes the head of Davis's Island, which, in the general plan of shutting off the water escaping down the left of Neville Island, I had estimated, in my annual report for the year ending June, 1867, would require a dam costing \$3,000. Since then I am satisfied that so little water takes this pass, it being dry at two and a half feet stage, that no sufficient advantage to extreme low-water navigation is attainable by the construction of such dam.]

Lowrie's Ripple, seven and a half miles from Pittsburg.—Length of ripple, 2,700 feet; fall, 2.14 feet; depth, 2 feet; velocity, 2.51 miles an hour. The channel is crooked, but never less than two feet; between the hard gravel bars it is narrow. The bars, however, are very low, and are safely passed at a coal-boat stage. The tow-boat owners, at their own expense, removed the rocks at the left hand bar at the head of Lowrie's Ripple. There are a few loose stones remaining yet, which, at the lowest water for coal-boats, are considered dangerous. They can be removed at the lowest water by two men in a few days, in conjunction with the work at Horse Tail Ripple.

Duff's Bar, eight and a quarter miles from Pittsburg.—At Duff's Bar, channel, 4,130 feet long; fall, 2.56 feet; depth, 2 feet; width of low-water channel, 112 feet; velocity, 2.21 miles; and channel straight but narrow. Rocks on the right and gravel bar on the left; through the bar here there was a dug chute formerly. In 1844 a dam was built, running square out at the head of Duff's Bar, extending over 300 feet. The old dug chute is not now used. Channel is further out, and has two feet water at lowest stage. The old wing dam, formed by scraping up gravel, never gets dry. It might have some good effect if raised higher. In connection with a thorough and general low-water improvement of the river I have estimated this work to cost \$2,000.

Good water from foot of Duff's to Merriman's Ripple, say two miles.

Merriman's Ripple, ten and a quarter miles from Pittsburg.—Length, 2,900 feet; fall, 1.86; depth, $1\frac{1}{2}$ feet; velocity, 2 miles an hour. A large bar on the left here, which formerly came out at a six-foot stage, does not appear dry now until the river has fallen to a four and a half stage. This difference has only been noticed since the improvement of White's Ripple dam, showing that the water through Merriman is backed up $1\frac{1}{2}$ feet, at a four-and-a-half stage. The effect has been also a marked decrease in the force of the current in this ripple, a bar on the right formerly showing at a two-and-a-half-foot stage is not now dry until the water has fallen to 20 inches in the channel by the Pittsburg marks. Channel between these bars runs close in to the right shore, as shown in the chart. No trouble if the channel is kept. The upper bar is quite troublesome to tow-boat men; the main difficulty being in trying to avoid the upper, they drift on to the lower bar, where a large quantity of coal has been lost. A very desirable improvement would be to dredge off the right hand point, so as to widen the tow-boat channel. About 3,500 cubic yards should be removed. The material could be deposited on the left bar, to act as a breakwater or high-water dam. A special chart accompanying the maps and profiles exhibits these points very clearly.

Good water from Merriman's to White's, say one-third of a mile.

White's Ripple, eleven miles from Pittsburg.—Length, 1,738 feet; fall, 2.64 feet; depth, 2 feet 2 inches; velocity, 3 miles an hour, (1838.) White's Ripple was, before the commencement of the improvement now being worked upon, the worst point for tow-boats on the entire river. The channel ran along the riprap dam to opposite Hay's Run, and then turned to avoid a bar next the dam; thence back again to the dam at the point where the present cross-dam strikes to avoid a bar on the right. A heavy current running over the old, partly-finished dams, many boats were carried over and wrecked. During 1867, 5,000 cubic yards of stone were added to the dam, running from the foot of the tow-head, raising it about four feet higher for a distance of 1,500 feet; it not being very efficient, a second contract was made and 3,000 cubic yards more were placed along this dam and upon the old cross-dam, (shown in the chart,) but which had been nearly obliterated by time. My original plan, not altered until after the second letting for work, did not contemplate the reconstruction of the cross-dam; but from a study of this peculiar place, the water acting so differently at different stages, I am satisfied that the plan of carrying the whole line of dam down mid-river to a regular height will not prove so beneficial as the permanent reconstruction of the cross-dam, at the same time leaving a wide easy gap to the landing and saw-mills at Middletown on the left. With the little stone already placed upon the cross-dam it has had a very decided effect in restraining the strong current over the long dam; but as it will need

strengthening, and as also the upper end of the long dam, where the ice sets against it with great force, needs more material, a third contract for 2,700 cubic yards has been made; the stone for which has been quarried, and which only the condition of the river prevented being boated during last fall. Tow-boats in "flanking," to avoid striking their barges against the head of the long dam at White's Ripple, have frequently grounded on the Hay's Run bar, which had contracted the channel at this point to a width of 450 feet at an ordinary tow-boat stage. During the fall of 1868 about 2,000 cubic yards of that bar were dredged away, making a difference of more than a 100-foot channel width for boats drawing seven feet; at the same time the removal of the point of the bar has aided in a further decrease of the force of the current setting against the dam opposite. White's Ripple is very decidedly improved. I have had a special survey made of White's Ripple and vicinity, which shows the plan and work done here very clearly.

Wollery's Trap, eleven and three-quarters miles from Pittsburg.—Length, 2,300 feet; fall, 2.41 feet; depth, 16 inches; velocity, 2.51 miles an hour, in 1838; now, in extreme low-water stages the depth is about 2 feet. Nothing remains of the old dam at Wollery's. A low, flat bar now extends from its outline in to the right shore. In extreme low water the lower end of the trap is shoaler than any part of White's; but at present no boating is done. When this place becomes troublesome in that respect, White's Ripple and Wollery's Trap may be regarded as one continuous ripple.

Good water from Wollery's Trap to head of Deadman's Island, say two miles.

Deadman's Island Ripple, fourteen and one-fourth miles from Pittsburg.—Depth at head two feet.

Deadman's Ripple, fourteen and three-fourths miles from Pittsburg.—Length, 3,250 feet; fall, 4.41 feet; depth at foot, 18 inches; velocity, 3.21 miles an hour; channel at tow head, upper end of island, is narrow; gravel bar on both sides. Since the date of my first general report the farmers in this neighborhood have changed the course of Sewickley Creek, which formerly came in a mile above the foot of the island, so that now this stream strikes the river opposite the foot of the island. Soon after this new channel-course was made a rain-storm (in August, 1867) raised the creek so rapidly that it began to cave in its banks, and filled into the river a large bar of coarse gravel immediately in the channel, which at this place runs close to the natural shore bar; the tow-boatmen employed men for several weeks to clear off the largest stones upon it, and also to work on the old bar opposite, as the wash rendered it necessary that they should stand farther out, this new bar increasing the force of the current so that some boats had to warp through the ripple, and giving a great deal of trouble. A contract was made for its removal, which was accomplished during the fall of 1868, 3,100 cubic yards of gravel having been taken out of the channel; about 900 cubic yards were also taken off of the right-hand bar, 300 yards below, so that now a comparatively-straight and greatly-improved channel exists through the lower passes of Deadman's. The lower bar still requires a little additional work, and also some dredging at the head, as mentioned in my annual report for 1867, which was written before the new creek bar had been formed, which caused such a large increase on the original estimate of \$1,500. During 1869 the creek bar again washed out, but not so much as before. Further work at dredging is now required; and to prevent the creek from again filling up, the channel dredging along the edge of the central bar, so as to make the

channel nearer mid-river, should be resorted to; 4,500 yards of dredging may be required at this place.

Good, deep water from Deadman's to Little Sewickley Bar, say two miles.

Little Sewickley Bar, seventeen miles from Pittsburg.—Bar at the mouth of Little Sewickley's Creek, referred to as having 2 feet depth in channel in 1838, and 143 feet width. Tow-boats, when they can get out at all, generally run straight over the Sewickley Bar. There is a sharp bend in the regular low-water channel close in at the mouth of Little Sewickley, then crossing out to near the middle of the river a few boulders on the right-hand bar. They are shown on the chart. Their removal will greatly benefit the tow-boating and will widen the channel for low-water navigation. (In Captain Sanders's table this bar is inadvertently placed one mile too far up.) Opposite Big Sewickley there is deep water.

Good water from Little Sewickley to head of Logstown Bar, about one and three-quarters miles.

Logstown Bar, eighteen and three-fourths miles from Pittsburg.—As mentioned in my first general report on the Ohio River, dated December 20, 1866, the construction of the dam G F, and widening the break in the old dam H F, shown on Captain Sanders's chart, seemed advisable.

The first contract for 5,000 cubic yards was made in the winter of 1866 and 1867; the work was done in 1867; 5,000 cubic yards of stone being boated to the dam, leaving the main shore 300 feet above the point G, and terminating at F. The estimate being made before I had an opportunity of examining the place at low water, and before any particular plan was decided upon, was afterwards increased. A second contract was made for 1,275 cubic yards riprap stone, and the removal of 1,000 cubic yards of boulders and small stone, composing the old, partially-constructed dam from H to F.

During the summer of 1867, 1,160 feet in length of this dam was taken up; the material, much of which was quite small, was placed upon the new dam. The removal of this dam at once furnished a broad, easy channel for tow-boats, making a very decided improvement, which has been generally appreciated by river men.

The work upon the second contract was not finally closed until the spring of 1868. The dam D E was never carried far out, and the *low-water channel* still remains, as shown on the chart inside of the small bar; the new dam, however, greatly improves its navigation, particularly at the stages when the freight-boats are running, drawing all the water in the river. "Logstown Bar improvement is considered, by good river men, to be one of the best on the river."

Good water from Logstown Bar to Crow Island, say three miles.

Crow Island Foot, twenty and one-half miles from Pittsburg.—Lowest water in channel in 1838, 21 inches; no trouble here. Good water to Waller's Ripple, about two and three-fourths miles.

Waller's Ripple, twenty-two and one-fourth miles from Pittsburg.—Lowest water in channel in 1838, 2 feet; no trouble here. Good water to Lacock's Bar, about two and one-fourth miles.

Lacock's Bar, twenty-four and three-fourths miles from Pittsburg.—Just below Freedom the low-water channel is near the right shore; lowest depth in 1838 was 21 inches; no trouble when boats keep the channel. Tow-boats always run to left of bar. Good water to Beaver Shoals, about one and three-fourths miles.

Beaver Shoals Head, twenty-six and three-fourths miles from Pittsburg.—Middle 26½ miles; foot 27½ miles. In the lowest water of 1838, the channel depth was at the head and middle 30 inches, and at the foot 18

inches. Captain Sanders proposed to open a new channel down the left shore, (A B; see chart,) the old channel about A D to be dammed, and the channel to be excavated at head about 100 yards in length, through solid rock, one foot deep. Some work was done, but the plan was not carried to completion. The plan for the improvement of this rough, dangerous piece of river is essentially that recommended in my annual report for the year ending June, 1867. I have had the place resurveyed and find that the boulder reef at the head, extending from the upper crossing down to the funnel chute, a distance of 700 feet, averaging 60 feet wide, should be dredged away, and the material thrown across the chute formerly proposed, close down the left, by Captain Sanders, and partially excavated, (through solid rock at one point,) to aid in concentrating the water down the middle of the river.

During the fall of 1868, a contract was accordingly made for 11,000 cubic yards of dredging at Beaver Shoals, and during the summer of 1869 this work was done. The funnel-chute bar described above was removed; it contained nearly 6,000 cubic yards of coarse, heavy boulders. The machine worked with difficulty, and many delays were experienced owing to accidents to the machinery. The material was thrown across Sanders's Chute to aid in building a dam. During 1868 a contract for 3,500 cubic yards of stone was entered into, and during the progress of the dredging it was quarried from the adjoining hills. It will be placed on top of the artificial boulder reef made of the excavated material during the present season, (1870.) The dredge-boat also removed several thousand yards of gravel at the lower end of the Beaver Shoals. But little more work will be required to thoroughly improve this place.

Good water and nearly straight river from foot of Beaver to Raccoon Shoals, about two and a quarter miles.

Raccoon Shoals, twenty-nine miles from Pittsburg.—Channel depth in 1838, 20 inches in middle, 15 inches below middle, and 25 inches at lower end. Wing-dams, one on each side of the channel, were proposed in 1838, but no work has been done. At a tow-boat stage the bar is passed over on the left, this channel being straighter than the one on the right. At 30 miles is the lowest chute, called Raccoon Bar; it had 27 inches in the channel in 1838 opposite Raccoon Creek. The shoal water ends here. Good water from Raccoon Creek to Montgomery Island, about two miles.

Montgomery Island, thirty-two miles from Pittsburg.—In 1838 lowest water was two feet; channel is on left of island. There were a number of rocks near the foot of the island, (33 miles;) many of them have been taken out by the tow-boat men. A few remain; they should be removed. The sum of \$200 is estimated for this work.

Safe Harbor, opposite Industry, thirty-three and a half miles from Pittsburg.—Good water from foot of Montgomery Island to Phillis Island, about two miles.

Phillis Island, thirty-five miles from Pittsburg.—Channel on right. In 1838 the channel at the head of the island was 22 inches deep; length of ripple, 400 feet; fall, 1.16-foot; width, 101 feet; velocity, 3.51 miles an hour. Only at extreme low water must this curved channel be strictly followed; at a tow-boat stage it is run straight by tow-boats. A few rocks are marked at foot of island; but when tow-boats run they pass over them. Their removal, it is estimated, will cost \$200.

Good water from Phillis Island to Georgetown Bar, about two miles.

Georgetown Island, thirty-eight miles from Pittsburg.—Channel on left. In 1838 lowest water depth at lower end, 23 inches. Length of ripple, 5,280 feet; fall, 1.85-foot. There is now good water in the chan-

nel at all times. At tow-boat stage there is a point at upper end of island, with a few large rocks mixed in with boulders, which is a little troublesome, especially when the boats are drawing all the water. Several of them may require blasting. The sum of \$300 is estimated for this place.

Good water from Georgetown Island to Line Island, about two and one-half miles.

Line Island, forty-one miles from Pittsburg.—In 1838 length of ripple, 400 feet; fall, 1.20-foot; depth, 2 feet; channel width, 93 feet; velocity, 4.21 miles an hour. The channel is quite narrow at the head of Line Island, between the bar on the left (which comes out at a three-foot stage) and the island. This place was let for improvement in 1868; 500 cubic yards of the top of this small bar were to have been removed, but the contract expired before the contractors could get through with the difficult work at Beaver. Some rocks are marked on the chart, half-way down the island. These are very low, and none are in the low-water channel. Tow-boats pass over them at a safe running stage.

Good water from Line Island to lower end of Babb's Island, one and one-half miles.

Babb's Island foot, forty-three miles from Pittsburg.—Depth of channel in 1838 at foot of Babb's Island, 22 inches. Velocity of stream in low water at head of island, $2\frac{1}{8}$ miles an hour. Captain Sanders reported some rocks to be removed. The rocks are not in the channel, and in the present system of boating they are not materially in the way. Tow-boats run over them.

Good water from foot of Babb's Island to Wellsville Bar, a distance of four miles.

Wellsville Bar, forty-seven miles from Pittsburg.—Lowest water in 1838, 2 feet. No trouble here, only to avoid the bar on the right hand, caused by Little Yellow Creek; some rocks, marked on the chart, near left shore.

Good, deep, straight river to bar above Baker's Island, about two miles.

Baker's Island, forty-nine and one-half miles from Pittsburg.—Head of island $49\frac{1}{2}$ miles. A dam was partly finished above head of Baker's Island. Boats only run the channel (correctly marked on chart) at extreme low water. The depth in low water in 1838 was 18 inches, now about 2 feet. The dam here should be finished in connection with the general low-water plans for improvement, as a great deal of water leaks through it which would further aid navigation. In all 2,500 cubic yards of stone will be required here to thoroughly improve this place. The rocks on right, below the shore bar, are not dangerous.

Good water to near Clusters, about two miles.

Clusters, fifty-two miles from Pittsburg.—In 1838 the depth at the upper end of the channel was 2 feet; at lower end 17 inches. The channel is nearly straight at lower point for extreme low-water navigation. A dam was planned here by Captain Sanders in 1844. To build it properly will require 5,000 or 6,000 cubic yards of stone. There is no doubt that the concentration of the water by a dam would be beneficial to navigation here; but the improvement of this place may, however, properly be deferred until other more important places have been thoroughly improved. Harding's Run Bar does not interfere with navigation.

Good water from Clusters to Black's Island, about two miles.

Black's Island, fifty-four miles from Pittsburg.—Depth of channel in 1838 was twenty-one inches; velocity, 2.81 miles an hour; length

of ripples, 8,750 feet; fall, 2.81 feet. Curved dam was proposed in 1838, from right shore to head of island; it was afterwards nearly completed, and has done good. This dam should be completed and a few rocks removed. The dam will require 1,500 cubic yards of stone. The depth of the water is not now less than two feet in extreme low water. The bend in the channel is sharp, but easily made by most pilots.

Good water to Brown's Island, nearly seven miles. King's Creek Bar is not in the way of tow-boats, $60\frac{1}{4}$ miles.

Brown's Island, sixty and three-fourths miles from Pittsburg.—In 1838 the channel had 20 inches depth on left of island; length of ripple, 21,100 feet, (several included;) fall, 3.77 feet. The dam proposed by Captain Sanders, from right shore, was nearly completed in 1844, and has greatly benefited navigation. The main channel used to be down the right of the island, but it is now almost entirely closed, and willows are growing over it. The curved dam, on the left shore, one-third way down the island, was built in 1836-'37. The channel becomes quite shoal under the lower part of this dam. The dam at the head of the island needs some riprap, which, with closing the gaps in the curved dam, I have estimated would require 800 cubic yards of stone.

Good water to Will's Creek Bar, about four and three-fourths miles.

Cable's Eddy, sixty-four miles from Pittsburg.—There are rocks here along the left shore, but not dangerous to single boats. There is deep water about them; as, however, they are considerably in the way of tow-boats, interfering with their landing at nights, this being their stopping point, to avoid running the Steubenville bridge in the dark, work for removing them has been let; in all there was estimated to be about 150 cubic yards to be blasted, which work was accomplished during the summer of 1869.

Will's Creek Bar, sixty-five miles from Pittsburg.—In 1838 there was two feet depth in low water for a very short distance; velocity, 2.81 miles an hour; length of ripple, 5,500 feet; fall, 2.86 feet, Ferry Bar included. There are rocks on the right and a gravel bar on the left, but there is no trouble here with the channel.

Good water to Ferry Bar, about one mile below.

Ferry Bar, sixty-six miles from Pittsburg.—Sometimes called Steubenville Bar. In 1838, 20 inches in shallowest part, opposite left-hand ferry landing, in middle of river. There are several rocks not materially in the way on the right, which should be taken out to widen the low-water channel. A number of rocks were taken out in 1844, and since then others have been removed through private enterprise. Several were removed during 1869.

Railroad bridge piers, sixty-six and one-third miles from Pittsburg.—Bridge of the Pittsburg, Columbus, and Cincinnati Railroad, a magnificent structure of eight cut-stone piers and iron superstructure. The center piers are about 300 feet apart, giving less than 260 feet water-way at low stages, owing to the riprap around them; the under side of the bridge on that span is 93 feet above low water. No cost seems to have been spared to make a permanent structure, and to give what was supposed to be a good water-way for the boats; nevertheless, a number of boats have already struck against the piers, and caused heavy losses, especially in the coal business. Prudent tow-boat pilots endeavor, by starting early in the morning from Pittsburg, to pass this bridge before dark, as it is considered very much more dangerous at night.

The company have thrown in riprap about all the piers, which in the case of the channel piers amounts to fully 20 feet obstruction to coal-

boats on each side, when there is only nine feet in the river. This reduces the actual water-way, when probably the heaviest coal business is done, practically to 260 feet—much too narrow for the safe passage of coal fleets, which are usually from 150 to 180 feet wide, and from 450 to 650 feet in length. Whatever may be the needs of the railroad and the actual necessities which governed them in locating these channel piers but 300 feet apart, there is no doubt of the fact that they are very serious obstacles to the river navigation. There is a difficult bend in the river a mile above, besides bars which affect the current at divers stages differently. Pilots find trouble in straightening up to come through, being at one time drifted toward the right-hand pier, and at another time toward the left. The question of bridge locations and spans over our navigable streams having been taken up by Congress, it is to be hoped that definite laws will be passed, having an eye not only to railroad necessities, but also to the important river interests. Some rocks and the remains of a coffer-dam, which were temporary obstructions under the Steubenville bridge, were removed by the Government snag-boats in the summer of 1868, as were several wrecks also, which had accumulated from the year before. During the summer of 1867 also several wrecks were removed from the channel at this place. During the season of 1869 these piers were fruitful of disaster.

Steubenville, Ohio, sixty-seven and one-half miles from Pittsburg.—Good water from Ferry Bar to Wells Bar, two miles.

Wells Bar, sixty-eight miles from Pittsburg.—Just below Steubenville; in 1838 the channel depth was 2 feet; length 929 feet; fall, 1.15-foot; velocity, 1.81 mile an hour. Since 1838, the gravel and stones washing from Wells Run have filled the old channel, which used to bend close in to the right shore by the mouth of the run. The channel now runs down the middle of the river. It is wider, but not so deep as the old channel. The old channel has not been run for seven or eight years. A dam was proposed by Captain Sanders at this place, but as all the water takes the channel at present, a dam could be of no benefit; it is only at low water that the place gives trouble. Some boats which passed the Sisters, formerly a much worse point, have had trouble here. The further improvement of the Sisters, or Twin Islands, will in this way give prominence to this and other bars, formerly easy to pass in comparison with that place. In a more general way this remark is applicable to all the improvements, the worst being considerably improved; the second-rate bad points next appear troublesome, though in these cases the second-rate places can generally be more easily improved, and with less cost. Fifteen inches additional depth upon the bad shoals, makes eight inches more necessary on the second-rate, if the full advantage of the additional depth is to be secured to the river commerce. At this particular place, as the bottom is hard gravel, I would advise dredging; 700 cubic yards would suffice to make a greatly improved low-water channel, which I have estimated would cost \$1,000.

Good water to Mingo Island, about two miles.

Mingo Island, seventy miles from Pittsburg.—In 1838 there were two channels; the right channel had 14 inches, and the left had 18 inches depth. The length in the left channel was 1,600 feet; fall, 0.95 foot; velocity, 1.71 mile an hour. This was the ordinary channel. In 1844 a dam was built from the left shore to the head of the island, as planned by Captain Sanders. This dam, though not entirely finished, has done great good; and for the further improvement of low-water navigation this dam should be repaired; 500 cubic yards of stone appear to be necessary for this purpose. The old chart does not exhibit this dam. The channel is run down the right side of the island.

Good water to Cross Creek; two creeks, opposite sides, one and one-fourth mile.

Cross Creek, seventy-one and one-fourth miles from Pittsburg.—In 1838 there were 30 inches of water here; 1,900 feet long; 0.58 foot fall; velocity, 2.11 miles an hour. The channel between the bars is wide and easy. No trouble here.

Good water to Cox's Bar, about three-fourths of a mile.

Cox's Bar, seventy-two miles from Pittsburg.—There are a few lumps in the channel here which should be leveled down. Length of ripple, 2,400 feet; fall, 0.97 foot. No trouble to navigation, except in extreme low water. I have estimated \$500 for the improvement of this place.

Good water to Buffalo Creek Bar, about one and one-fourth mile.

Buffalo Creek Bar, seventy-four miles from Pittsburg.—Just below Wellsburg, Virginia, a big bar reaching from left side to middle of river, and some rocks below; a bar also on right side of the river; but the channel is good at all times. Length of ripple, 3,650 feet; fall, 0.44 foot. In extreme low water, in 1838, it showed four feet in channel.

La Grange, Ohio, seventy-four and one-fourth miles from Pittsburg.—Good water to Beach Bottom Bar, three and one-half miles.

Beach Bottom Bar, seventy-seven and one-half miles from Pittsburg.—In 1838, length of channel 2,575 feet; fall, 0.93 foot; depth, 17 inches; velocity, 1.51 mile an hour. The dam proposed by Captain Sanders was partly built in 1844, from the left shore to the tow-head. The dam was not built as shown by the red line on the chart; it is in reality much shorter, crossing more squarely, and does not lap so much on the bar. This dam should be completed. I have estimated it to require 2,500 cubic yards of stone.

Warren, Ohio, eighty and three-fourths miles from Pittsburg.—Good water to Indian Short Creek Bar, three and one-half miles.

Indian Short Creek Bar, eighty-one miles from Pittsburg.—Two creeks opposite Ohio and Virginia. In 1838, channel 2,200 feet long; fall, 0.98 foot; depth, 2 feet; bar on right in middle of river appears at 2-foot stage; high bars at both the short creeks; channel close to Virginia shore; the navigation is at all times easy. Good water to Pike's Island, about two miles.

Pike's Island, eighty-three miles from Pittsburg.—In 1838, channel length 5,470 feet; fall, 0.88 foot; depth in extreme low water, 18 inches. A dam was proposed by Captain Sanders, and partly built in 1844. There is never less than 2 feet here, and there does not appear to be any special necessity for work here at present. Good water to Twin Island, about one mile distant.

Twin Islands, eighty-four and one-fourth miles from Pittsburg.—In 1838, length of upper channel 3,250 feet; fall, 0.48 foot; depth, 31 inches; length of lower chute, 2,400 feet; fall, 1.21 foot; depth of channel, 18 inches; velocity, 2.51 miles an hour. The dam at the head of Pike's Island was the first plan designed to benefit navigation here, and also a dam connecting Pike's Island and the upper Twin. But the work as built is a dam partly finished, running obliquely to the left shore from the head of the upper Twin. A wide gap was left in the middle of the dam when Captain Sanders quitted, for want of means to complete the work, and very little stone had been placed between the gap and the island. This place was let for improvement early in 1867, and 4,000 cubic yards of stone were applied. Afterward, during 1867, it was found necessary to add 1,200 cubic yards to complete it. The dam has a total length of 2,900 feet, the most of it being new, and built upon comparatively soft gravel. In the winter of 1867 and 1868 the floods

washing over it caused it to settle. During the progress of the work, the settling consumed such a large amount of the contract quantity, that the dam was not brought to its proposed dimensions. In the fall of 1868, a third contract for 1,650 cubic yards was made, but so late in the season that the contractor was compelled to suspend work after boating 800 cubic yards to this dam.

In the last contract provision was also made for the construction of a short spur-dam, to leave the foot of the island crossing to a bar, which divides the water at the shoal as effectively as did the island formerly. Two hundred cubic yards were boated to this dam, but so late in the season of 1868 that its operation could not be observed on account of high water. During 1869 this work was done, but the settling having further continued, it would be highly advisable to rebuild portions of the work. A moderate amount of dredging, to deepen and particularly to straighten the channel through the shoal, will be advisable. The case is peculiar at Twin Island; it has been for years noted as the worst point below Glasshouse Ripple, near Pittsburg, being 10 inches shoaler than the bars immediately above and all below it on the river. River men are particularly interested in its improvement. There has already been a considerable improvement shown, by boats having passed this place and found difficulty at Wells Bar and other points equal in depth. This exhibits an improvement here, showing 10 inches more water than formerly. There can be no doubt that another summer's work, particularly if a little dredging is done, will make this place nearly two feet deeper, for ordinary low-water boating, than formerly.

Good water to Burlington Bar, about two miles.

Burlington Bar, eighty-six and one-fourth miles from Pittsburg.—In 1838, channel 1,935 feet long; fall, 0.76 foot; depth, 22 inches; velocity, 2.11 miles an hour. Captain Sanders planned a wing-dam here, to extend from the left shore out to mid-river, and thence around, so as to confine all the water near the channel. With the improvement of other points, it will be found advisable to build this dam; it will be 2,000 feet long, but passing through shoal water, will not require in all more than 6,000 cubic yards of stone. It is probable that the dam closing the right of Wheeling Island might make further work here unnecessary, which will be seen during the present season, 1870. (See my special report on Wheeling Island, February 12, 1869.)

Good water to head of Wheeling Island, two and one-quarter miles.

Wheeling Island Head, eighty-eight and one-half miles from Pittsburg.—In 1838 the channel on left side at head, 7,725 feet long; fall, 2.66 feet; depth, 22 inches; velocity, 2.21 miles an hour. The channel, at foot, 5,700 feet long; fall, 1.79 foot; depth, 18 inches; velocity, 1.91 mile an hour. Velocity of water at Wheeling, 2.71 miles an hour. Captain Sanders, in 1838, proposed a dam to close the right channel at the head, and a small dam between two bars in the left channel, but no work has ever been done.

Work was advertised during the fall of 1868, for 6,000 cubic yards of stone, to close the Ohio chute of this island. The citizens of Bridgeport and vicinity, half way down the Ohio chute, sent remonstrances to me, which were forwarded to the Department. These people believed that the closing of the Ohio chute would be a serious injury to their business on the river, and asked that some other plan be adopted. By order of the Department I had a special survey made of this island, showing the channels, &c., here, with the town of Bridgeport, location of its saw-mill, coal tipple, &c. In a special report, dated February 12, 1869, upon this place, with an accompanying map, these details were set forth more

at length. During the low water of September, 1867, the engineering party on the United States steamer Tidioute gauged the flow passing Wheeling through the Wheeling Island chutes. At a 14-inch stage in the channel they found the flowage to be, on the right or Bridgeport side, 43,000 cubic feet per minute; on the left, or Wheeling side, 137,000 cubic feet per minute; total Ohio River, at Wheeling, 14-inch stage, 180,000 cubic feet per minute. At that low stage neither rafts nor flat-boats could navigate the Ohio chute, while the addition of its water greatly improved the regular channel down the Virginia chute, benefiting both the shoals at the head and foot of the island. After the survey of the island, it was finally decided to construct a dam closing the Ohio chute below the Bridgeport bridge. This met with no opposition from the citizens of Bridgeport, but rendered the construction of the dam more difficult. During the summer and fall of 1869, 6,000 cubic yards of stone were placed on this dam. It cut out in the central portion to the depth of 15 feet, and much difficulty surrounded the work on account of the swiftness of the water; besides, also, the island bank cut out and gave considerable trouble. The bank had finally to be protected with brush and pickets.

It is likely this dam will require attention for a year or two. It had the immediate effect of adding about a foot of water to the Wheeling channel marks on the opposite side of the island.

If it be made finally secure, no other work will, in all probability, be required. The channel at Wheeling Creek was also dredged to the extent of 2,000 cubic yards, during the fall of 1869.

Mouth of Wheeling Creek, ninety miles from Pittsburg.—About one mile above the foot of Wheeling Island, shoal water, and bar below the creek not essentially different from what it was in 1838, when at extreme low water the channel depth was 18 inches. The dam referred to at length above, to confine all the water passing the island to the Virginia chute, has been of great benefit to this shoal. In length this ripple is 1,000 feet; fall, 1.79-foot. It was a very troublesome place, as boats had often for weeks to land their freight below this point, whence it had to be hauled in wagons to the business portions of the city of Wheeling, the landing being half a mile above.

Good water from foot of Wheeling Island to Bogg's Island, two miles.

Bogg's Island, ninety-two and one-half miles from Pittsburg.—In 1838, length of channel, 3,976 feet; fall, 1.97 foot; width, 383 feet; depth, 18 inches; velocity, 2.51 miles an hour. It is a shoal place, but no dam has been proposed. A few rocks and stones at the lower end of the bar might be picked off with advantage to navigation. This work could be accomplished at a cost of \$400, as heretofore estimated.

Good water to McMahon's Bar, about one and one-half miles.

McMahon's Creek Bar, ninety-four miles from Pittsburg.—In 1838, length of channel, 2,500 feet; fall, 2.29 feet; width, 725 feet; depth, 20 inches; velocity, 2.31 miles an hour. Not much trouble now on the bar. No work was done here by Government. The channel as marked on the chart, on right side, is usually followed. Captain Sanders, in 1838, proposed to close the right hand channel with a wing-dam. In its present condition no dam seems advisable, nor could one well be placed which would not interfere with navigation. It is one of those few places where dredging would seem to be the best plan; 5,000 cubic yards of excavation seem to be required, the material of which could be employed in filling or banking the channel into one chute.

Good water in channel, to Little Grave Creek Bar, six miles. There

are some shoals for the first two miles, and the low-water channel is a little curved, but there is no trouble in this place.

Little Grave Creek Bar, one hundred miles from Pittsburg.—In 1838, length of channel, 2,900 feet; fall, 1.87-foot; depth, 30 inches; velocity, 2.51 miles an hour. Channel keeps near the Ohio shore, and is easy for boats at all times.

Good water to Big Grave Creek Bar, about two miles.

Big Grave Creek Bar, one hundred and two miles from Pittsburg.—In 1838, length of channel, 1,587 feet; fall, 1.18-foot; width, 420 feet; depth, 30 inches; velocity, 3.81 miles an hour. Gravel bar on the right; rock on the left; always plenty of water; no trouble in channel at any time.

Good water to Captina Island, about five miles. At one hundred and fifth mile, Narrow's Run, on the Ohio side, has a small gravel bar opposite; dry at a two and a half feet stage; but there is always good water in the channel.

Captina Island, one hundred and six and three-fourths miles from Pittsburg.—In 1838, length of channel, 7,200 feet; fall, 3.65 feet; width, 270 feet; depth, upper end, 10 inches, before improvement, and 18 inches after improvement in new channel. Before the dam was built, in 1838 and 1839, the channel was on the left side of the island. A dam was partly built across that channel, and the navigation has been on the right side since 1838. Early in 1867, a contract was made for furnishing and delivering 3,000 cubic yards upon this dam. This work being accomplished early in the season, and the new work having settled near the island end, a supplementary contract for 1,000 cubic yards was made, the work of which was finished, and the dam substantially built, so as to turn all the water, at a $7\frac{1}{2}$ -foot stage, before winter. In the spring of 1868, it was found that the floods of the previous winter had further settled this dam, particularly at one place, where, for 60 feet, it had bodily dropped in the sand to the depth of 4 feet below the general top range of the dam. A third contract for repairs, 550 cubic yards of stone, was made, but so late in the fall of 1868 that work ceased for that season after about 180 cubic yards had been placed upon it. The dam is one of the strongest yet built on the river, and it is believed, with the slight repairs finished in 1869, it will hereafter remain intact. Some riprap dams, built upon apparently good solid gravel, require attention for several years, the settling referred to being beyond human control. After such a dam has stood a year or two, and become compact with gravel, like the main portions of this dam, it becomes permanent. Captina Island has given no trouble at ordinary low water, since the work was done upon this dam; but at an extreme low stage, when the pools are drained by natural flow and the rapid summer evaporation, the small boats running have at times found trouble with the rough bottom in the ripple. Private individuals have removed a quantity of the coarse boulders from this place, but to make effective improvement there was let, with the third contract, 500 cubic yards of river excavations at this place. This work was to have been done in 1869, but the time of the contract expired before circumstances were favorable. A narrow backbone bar, running just outside, about the mouth of Little Captina Creek, might be scraped away with advantage to low-water navigation. A few stones from the mouth of the creek, down, might also be removed. At a tow-boat stage there is no trouble, as all the bars are covered when they can run from above.

Good water to Captina Creek, (at Captina Creek there were thirty-nine inches in 1838,) and good thence to Fish Creek, in all about five miles.

Captina Creek, one hundred and eight and three-fourths miles from Pittsburg.—At Powhattan Point shoals on the right but good water on the left; in channel, 3 feet 3 inches at low water of 1838; nothing needed here.

Fish Creek Island, one hundred and twelve miles from Pittsburg.—Right channel in 1838, length, 3,150 feet; fall, 2.12 feet; width, 203 feet; depth, 18 inches; velocity, 2.11 miles an hour. Left channel 1838, length, 2,850 feet; fall, 1.53 feet; width, 212 feet; depth, 18 inches; velocity, 3.81 miles an hour. In 1844 a dam was partly built. In former times, in low water, the channel was sometimes on the left side, but in a fair stage it was always where it is now, on the right side. The dam was thrown across nearly as shown on the old chart. Proposals were received for furnishing 4,000 cubic yards for this dam in 1867, and the work was finished during the summer; 2,760 cubic yards only being required and used. During the winter of 1867-'68, as with Captina Dam, 5 miles above, it settled and washed at several points. There were no rises, excepting one in August, which rose only six feet in 1867, until late in December, so that the ice floods came before any gravel had been washed into the newly made dams. A second contract for 400 cubic yards to repair this place was made in the fall of 1868; only about 50 cubic yards were boated in before the high water in November stopped the work for the season. During 1869 the repairs were completed. Fish Creek Island has given no trouble to navigation at any time since the work was begun in 1867.

Johnson's Bar, commonly known as Kline's, one hundred and fourteen and one-half miles from Pittsburg.—Length of channel, 2,992 feet; fall, 2.79 feet; width, 218 feet; depth, 2 feet; velocity, 2.11 miles an hour. The channel is straight, and there is no trouble here at any time.

Sunfish Town, Ohio, one hundred and seventeen miles from Pittsburg.

Sunfish Creek Bar, one hundred and seventeen miles from Pittsburg.—In 1838 length of channel, 3,600 feet; fall, 0.36 feet; depth, 26 inches. A rock bar on right extends two-thirds way across the river; gravel bar on left; the channel between them is easy at all times.

Good water to Oppossum Creek Bar, two miles.

Oppossum Creek Bar, one hundred and nineteen miles from Pittsburg.—In 1838 length of channel, 3,600 feet; fall, 2.42 feet; width, 586 feet; depth, 18 inches; velocity, 2.21 miles an hour. The channel close to the left or Virginia shore gets shoal at extreme low water, coming down to 18 inches at times. This place has not heretofore given special trouble, but with the improvements already made and contemplated elsewhere work here will early be necessary. The channel, as will be seen on the chart, is too narrow to admit of dams which would not interfere with the coal-boat navigation. For low-water purposes hereafter dredging will have to be resorted to, which I would estimate at 4,000 cubic yards. In this place it will not be necessary to have the dredged channel for low-water purposes so wide as that required for tow-boats.

Good water from Oppossum to Roger's Bar, one and three-fourths miles.

Roger's Bar, one hundred and twenty and three-fourths miles from Pittsburg.—In 1838 length of channel, 1,650 feet; fall, 0.31 foot; depth, 38 inches; channel broad and easy; no difficulty.

Good water to Proctor's Run Bar, three-fourths of a mile.

Proctor's Run Bar, one hundred and twenty-one and one-half miles from Pittsburg.—In 1838 length of channel, 3,100 feet; fall, 0.49 foot; depth, 2 feet; in one spot short, high bar on the left; gravel bar on the right; no difficulty.

Good water to Dry Run Bar, one-half mile.

Dry Run Bar, one hundred and twenty-two miles from Pittsburg.—In 1838 depth, 30 inches; length of channel, 1,500 feet; fall, 0.20 foot; high bar on left; mouth of Hain's Run, Virginia; no difficulty.

Good water to Muckledowney Bar, three and one-half miles.

Muckledowney Bar, one hundred and twenty-five and one-half miles from Pittsburg.—In 1838 depth, 30 inches; length of channel, 2,000 feet; fall, 0.36 foot; channel bends in to near Virginia shore; no difficulty.

Good water to Fishing Creek Bar, about two miles.

Fishing Creek Bar, one hundred and twenty-seven and one-half miles from Pittsburg.—In 1838, right channel, length, 3,000 feet; fall, 2.06 feet; width, 435 feet; depth, 20 inches; velocity, 3.31 miles an hour. Left channel, length, 2,300 feet; fall, 1.76 feet; width, 330 feet; depth, 14 inches; velocity, 3 miles an hour. A dam was built in 1844 from the left or Virginia shore to the head of the bar, shutting the channel on the left side and improving the water in the present Ohio channel. This dam, by an addition of riprap, would further improve the navigation at this point, and with a complete low-water improvement of the river, 3,000 cubic yards of stone will be required. No other work necessary or advisable.

Good water to and past Peden's Island to Williamson's Island, five and three-fourth miles.

Peden's Island, one hundred and thirty-one miles from Pittsburg.—Depth, in 1838, 7 feet 3 inches; no difficulty. This channel is the best island channel on the river. At 132 miles is the head of Long Reach.

Good water to Williamson's Island, two miles.

Williamson's Island, one hundred and thirty-three and one-fourth miles from Pittsburg.—Length of channel, 4,000 feet; fall, 0.68 foot; depth, in 1838, 4 feet 3 inches. A dam was partly built in 1844, from the Virginia shore to head of island, to aid in confining the water at Whitten's Tow-head and Wells Island below. This dam should be completed. It will probably direct enough water past Whitten's Tow-head or Low Island, at the foot of Williamson's Island, to render unnecessary the repair of the dam at the latter place; in which case my estimate in annual report to the Department for the year ending June, 1867, for 3,500 cubic yards for Whitney's Tow-head, will not be required at present. With these views, I make no present estimate for the separate improvement of Whitten's Tow-head.

Whitten's Tow-head, one hundred and thirty-four and one-half miles from Pittsburg.—In 1838, length of channel, 3,475 feet; fall, 1.24 feet; depth, 18 inches; velocity, 1.81 miles an hour; channel good to foot of Williamson's Island. Whitten's Tow-head is connected with the island by a dam, referred to above, partially built in 1844; the channel is now tolerably good at this tow-head. At 137 miles, gravel bar at mouth of Pusley Creek, close to Virginia side; not in the way.

Good water from Whitten's Tow-head to Wells Island, about four miles.

Wells Island, one hundred and thirty-eight and one-fourth miles from Pittsburg.—In 1838, length of channel, 2,105 feet; fall, 0.76 foot; depth, 13 inches; velocity, 2.11 miles an hour. A dam was commenced in 1844, from the Virginia or left shore, to head of island. The dam should be completed for the benefit of a general improved low-water navigation; 3,500 cubic yards of stone will be required.

Good water to Mill Creek Island, two and one-fourth miles.

Mill Creek Island, one hundred and forty and one-half miles from Pittsburg.—In 1838, length of channel 4,350 feet; fall, 1.06 foot; depth, 18

inches; velocity, 2.21 miles an hour; dam partly built in 1844 from the Virginia shore to head of island. This dam has of late years been cutting out, and should early be repaired; 1,500 cubic yards of stone will complete it. There are also a few stones on the point of Mill Creek Bar which might be picked off to advantage. Their removal would seem to require no separate estimate.

Good water from mouth of Mill Creek to head of Grandview Island, about one mile.

Grandview Island, one hundred and forty-one and one-fourth miles from Pittsburg.—In 1838, channel 7,100 feet long; fall, 1 foot; depth, 2 feet. In 1844 a dam was partly built at head of island from Virginia shore. After the improvement at Grandview and Sheets' Ripple below, which are let out for work, it will, in all likelihood, be necessary to repair this old dam; 1,000 cubic yards may be necessary to make it turn all the water for the improvement of the low stages.

Grandview Shoals, one hundred and forty-three miles from Pittsburg.—In 1838, channel 7,325 feet long; fall, 1.35 foot; depth, 20 inches. This place is a wide shoal in the river, and formerly was not so bad, but with the late improvement at Petticoat Ripple, three miles below, (at the foot of the long reach which extends from Peden's Island to Petticoat Bar, sixteen miles,) it has given trouble. A dam leaving the Virginia shore about a mile below Grandview Island, was planned to extend out to mid-river and along the channel 500 feet, into the pool below; its whole length being about 1,800 feet, requiring 4,800 cubic yards. This work was let, with a number of other places, late in the fall of 1868, but not completed till late in the fall of 1869.

Shifttail Ripple, one hundred and forty-five and three-fourths miles from Pittsburg.—In 1838, channel 7,280 feet long; fall, 0.43 foot; depth, 18 inches. A general flat bar of nearly the same character as the Grandview Shoals; and, like the shoal at Grandview, the Petticoat Bar improvement has rendered improvement imperative at this point. The dam built during 1869 is, in general, the same shape as that built at Grandview, containing, also, 4,800 cubic yards of stone. It was let during the fall of 1868, and finished during the summer of 1869.

Petticoat Bar and Ripple, one hundred and forty-six and three-fourths miles from Pittsburg.—In 1838, channel 4,300 feet long; fall, 1.40 foot; depth, 15 inches. Two dams were partially built by Captain Sanders in 1844. The principal one on the left extends from the Virginia shore to mid-river, and thence down with a whole length of 1,800 feet. A small low dam on the right was found to be necessary to further confine the water. Early in 1867 a contract for 3,000 cubic yards of stone was made, and the main dam on the left was built about three feet higher. Afterwards, in the same season, a second contract for 500 cubic yards of stone was made, and the dam on the right was thoroughly repaired. At present no further work appears necessary. This place, until the completion of the last work, was always troublesome at low water, but it has been greatly improved, showing at a three-and-a-half-foot stage, nearly two feet better water than formerly, which makes it now superior to many other points formerly much less troublesome.

Good water for four miles, to Grape and Bat Islands.

Grape and Bat Islands, one hundred and fifty and three-fourths miles from Pittsburg.—In 1838, channel 1,380 feet long; fall, 0.52 foot; width, 220 feet; depth, 30 inches; velocity, 2.61 miles an hour. Rock bar on right channel down these islands, gravel along the left side. The channel is narrow at low water, but deep. Tow-boats have no trouble.

Middle Island, one hundred and fifty-two miles from Pittsburg.—In 1838,

channel 2,700 feet long; fall, 1.80 foot; depth, 21 inches. The bottom is rough with boulders, but no particular difficulty is experienced here. Middle Island is a very large island, about $2\frac{1}{2}$ miles long. The old chart does not exhibit it correctly. The discharge of water in the river was measured along the part of the stream in 1838 during low water, and found to be 149,195 cubic feet per minute. Good water to head of Three Brothers Island, five miles.

Head Three Brothers Island, one hundred and fifty-seven and one-fourth miles from Pittsburg.

Rowland's Race, one hundred and fifty-eight and one-fourth miles from Pittsburg.—In 1838, channel 2,070 feet long; fall, 1.66 foot; width, 247 feet; depth, 23 inches; velocity, 3.37 miles an hour; flow of water in 1838, 149,195 cubic feet per minute. A dam was partly built in 1844, from the Virginia shore to head of second island. Near the foot is the "Race," where the channel is very narrow, and for low-water boating crooked. A contract for the removal of 1,200 cubic yards of gravel at this place to straighten the channel was made, but so late in the season of 1868 that the high water prevented the work from being done till 1869. No trouble for tow-boating. There is good water along the lower end of "Three Brothers." At the foot a gravel bar on the left comes out at a three-foot stage.

Lower end Three Brothers Island, one hundred and fifty-nine and three-fourths miles from Pittsburg.—In 1838 the depth was 3 feet in the channel. No trouble. Good water to Henderson's tow-head, one mile.

Henderson's Tow-head, one hundred and sixty and three-fourths miles from Pittsburg.—In 1838 there were 4 feet of water in the channel. No trouble here.

Good water to Bull Creek Bar, three and one-fourth miles.

Bull Creek Bar, one hundred and sixty-four miles from Pittsburg.—Length of channel, 2,000 feet; fall, 0.28 foot. In 1838, 18 inches in the channel; it is a low flat bar. No particular difficulty experienced here, excepting in extreme low water. This place is similar, in some respects, to Carpenter's Bar, next below. The effect of other improvements (particularly that proposed for Carpenter's Bar) yet to be made will govern the construction of a dam here. At present the heavy boats stop running before this shoal gives trouble. It would require at least 5,000 cubic yards to build a dam for its separate improvement.

The dam, if built, will swing out from the Virginia side with a length of about 1,800 feet.

Good water to Carpenter's Bar, two miles.

Carpenter's Bar, one hundred and sixty-six miles from Pittsburg.—In 1838, length of channel 3,530 feet; fall, 1.52-foot; depth, 18 inches. This place is now one of the worst shoals on the river, and becomes more especially troublesome with the improvement of other points. The river wastes over its whole width, making no good or regular channel, and steamboats are continually sticking and throwing up lumps, making it much worse than if left to its natural condition. This, however, is an evil not wholly to be prevented in the case of low-water improvement. The place could easily be improved by a dam, which Captain Sanders originally proposed should extend obliquely down from the Virginia shore, two-thirds over, so as to contract the excessive width. With the hope that closing either chute of Marietta Island, one and one-third mile below, would back the water sufficiently, he delayed work, and as no dam was built at Marietta Island, it has remained as it was. A special report on Marietta Island, dated February 15, 1869, embraces more fully the cognate question of the improvement of Carpenter's Bar.

In my annual report for the year ending June 30, 1867, it was estimated that a dam here would require 10,000 cubic yards, with a note that it might not be necessary, should the Marietta Island dam prove sufficient.

Good water to head of Marietta Island, one and three-fourths mile.

Marietta Island head, one hundred and sixty-seven and three-fourths miles from Pittsburg.—In 1838, the right channel 4,650 feet long; fall, 0.66 foot; depth, 3 feet. Duck Creek bar, in right channel, one and three-fourths mile head, had only 22 inches.

Duck Creek Bar, on right side of Marietta Island, one hundred and sixty-nine and a half miles from Pittsburg.—In 1838, channel 850 feet long; fall, 0.53 foot; depth, 22 inches.

Foot of Marietta Island, one hundred and seventy-one miles from Pittsburg.—Length of channel, 6,000 feet; fall, 1.47 foot; depth in 1838, right channel, 16 inches.

Marietta Island, left channel, in 1838, only 10 inches deep.

Marietta, Ohio, one hundred and seventy-one miles from Pittsburg.—Muskingum River enters on Ohio side, at lower end of Marietta; Har-mar on lower side of mouth. In regard to the improvement of the navigation at Marietta Island, Captain Sanders proposed a dam at the head from the left or Virginia shore to close the Virginia channel, and a jetty at the foot of the island, but he made a note on the chart, "jetty at foot of island may not be required." I have heretofore corresponded with the Department upon the subject of the improvement of this difficult place. It has become virtually the head of the improved low-water navigation since the improvement of Blennerhassett's and Buffington Islands, points below it which were formerly much worse. The further improvement of Buffington increases the necessity of improvement here; as it is, Marietta is a sticking point for all boats wishing to ascend above the city of Marietta. During the fall of 1868 a contract for furnishing and delivering 10,000 cubic yards of stone to close the Ohio chute of this island was made, but before work was commenced a remonstrance from some of the Marietta people was received, which was forwarded to the Department with a report dated October 3, 1868.

In advance of actual construction of the dam authority was granted for the quarrying of the stone, its disposition to be governed by what may hereafter be decided upon; there being no doubt that the stone can be used to great advantage in this vicinity. It was quarried in 1869. My special report and accompanying map, referred to above, the surveys for which were especially directed to the question of these channels, give more particular information in regard to the construction of dams, &c., at this point.

Either channel at Marietta Island could be benefited by a dam at the head. The left channel is the more natural one, and after passing its shoal water at the upper end there is no more trouble; whereas, although the right or Ohio channel is better at the head, it is impeded by the shifting sand-bar at the mouth of Duck Creek, and the changeable bar at the mouth of the Muskingum River, and is in general rather the more difficult channel; but on account of the importance of Marietta and the wishes of river men it may be advisable to close the left or Virginia chute.

Good water from the foot of Marietta Island to the head of Muskingum Island, three miles.

Head of Muskingum, one hundred and seventy-four miles from Pittsburg.—In 1838 the right channel 3,020 feet long; fall, 1.38 foot; depth, 14 inches.

Muskingum Island, middle, one hundred and seventy-five miles from Pittsburg.

Muskingum Island, foot, one hundred and seventy-six miles from Pittsburg.—In 1838, channel length, 4,750 feet; fall, 1.41 foot; depth, 20 inches, left channel. In 1838, left channel depth, 20 inches. The dam proposed at the head of Muskingum Island, in 1839, was across the Ohio channel, as shown by red line on the chart. The Virginia side was then the channel run, but the dam, as in part built in 1844, is across the Virginia channel. A little work was done at each end of the dam, but no stone was put in across the channel. A contract for furnishing and delivering 4,000 cubic yards of stone for this dam was made in 1867. This estimate, as were all those made early in 1867, was submitted before there had been opportunity to examine the places carefully in low water. It was found that nine hundred feet of the central portion ran through water nine feet deep at the lowest stage, which involved a considerable supplementary estimate. The second contract made in 1867 was for 4,800 cubic yards of stone. The same contractor had the Blennerhassett Island dam, nine miles below, and being directed to work both forces at the latter place upon different occasions, was not enabled to finish at Muskingum Island until the fall of 1868. The dam, as completed, is not quite so high as some of the others, but directs all the water into the right chute up to a five-and-one-half-feet stage. It has greatly improved the low-water navigation, backing up water even to Marietta, and somewhat improving the shoal extending in front of that place, going into its landing. No further work appears to be necessary at Muskingum.

The channel is good to Vienna Island, three miles below head of Muskingum Island.

Vienna Island, one hundred and seventy-seven miles from Pittsburg.—Vienna (James in old chart) had, in 1838, in channel two feet; length of channel 3,500 feet; fall 0.97 foot. The channel is straight over this bar, wide, and good water in an ordinary low stage. For its improvement in the lowest stages, which may in the future be demanded, it is believed that the proposed repairs to the Cole's Island dam, three miles below, will back up water enough to make navigation at this place equal to other improved shoals.

Good water to Cole's Island, three miles.

Cole's Island, one hundred and eighty miles from Pittsburg.—In 1838, channel length, 3,000 feet; fall, 2.47 feet; width, 135 feet; depth, 21 inches; velocity, 2.81 miles an hour; flow of water in 1838, 153,525 cubic feet per minute. Cole's Island was formerly called James Island. A dam was partly built in 1844 from the left or Virginia shore to head of Cole's Island. At extreme low water there was sometimes trouble in the channel at the head of the island. If the dam were finished, there would probably be no difficulty. It would not require much work to finish it, not more than 500 cubic yards; and very fine stone, the same used in the Parkersburg bridge, is found on the Ohio shore one mile above. Perhaps the refuse stone about these quarries might finish the dam. This place was formerly somewhat shoaler than Vienna Island, but since the improvement made at the head of Blennerhassett's Island, four and one-fourth miles below, the ripple has nearly disappeared, with, of course, an improved depth on the shoal. The effect of the Blennerhassett dam, as soon as finished, was noticed by a rise of about two and one-half feet at the town of Parkersburg, two miles above. This rise extended itself up the Little Kanawha River three miles, and virtually "killed" the first ripple on the stream, which inter-

fered with its navigation. In planning the low-water improvement on the river, we look constantly at this connection, watching how one improvement affects another. This is one of the leading features, and while no single shoal can be neglected without detriment to the value of all the other improvements, the efficient improvement of one, as in this instance, sometimes proves of great benefit to other places.

Parkersburg, West Virginia, mouth of Little Kanawa, one hundred and eighty-three and a half miles from Pittsburg.—Good water from Cole's Island foot to head of Blennerhassett's Island, 3 miles.

Blennerhassett's Island, head, one hundred and eighty-five miles from Pittsburg.—In 1838 the right channel length, 2,150 feet; fall, 1.19 foot; width, 378 feet; depth, 30 inches; velocity, 2 miles an hour; area of cross section, 869.4 feet; flow, 133,455 cubic feet per minute. Middle channel, 2 feet deep.

Tow Head, one hundred and eighty-eight and a half miles from Pittsburg.—Below channel, length 6,550 feet; fall, 2.27 feet; depth, 30 inches.

Head Left Channel.—In 1838, length 7,433 feet; fall, 3.91 feet; depth, 10 inches.

Left Channel, middle.—In 1838, length 1,430 feet; fall, 0.61 foot; width, 77 feet; depth, 1 foot; velocity, 1.81 mile an hour; area of cross section, 100.1 feet; cubic feet flow, 18,796; united flow of the two channels in 1838, 152,251 cubic feet.

In 1844 Captain Sanders built a dam closing the Virginia chute at the head of the island, and also commenced work upon a short dam connecting the foot of the main island with a tow-head below the island. Very little work was, however, done upon the lower dam. The dam at the head, on account of the great depth of the water, (to save distance,) was carried nearly square across from the Virginia shore to the head of the island. It was about 1,200 feet long, passing through water for 800 feet fully 14 feet in depth at low water. The entire width of base, at present, in the widest part is about 120 feet. This great width, however, is owing to the dam having been washed and knocked down by the ice, &c. I have no data which exhibit the quantity of stone placed in the work by Captain Sanders, but have estimated it at fully 18,000 cubic yards. The difficulty in the navigation is four miles below the head of the island, being a shifting shoal bar between the tow-head and the Ohio shore. This place has long been accounted one of the worst sticking-points below Parkersburg on the river. The channel along the island on the right is good all the way down, but with a steep, abrupt, sandy bank, almost a cliff, at one point. The water, being swift, carries the sand and gravel along, depositing it where the force of the ripple expends itself against the comparatively still water in the deep pool below. A peculiarity of this place was that it often gave trouble in good boating stages, and again, after a time, in extreme low water, a comparatively good narrow channel would cut through. But there was never anything certain or reliable in this cutting process.

Early in 1867, before I had an opportunity of examining the locality in low water, contract for 5,000 cubic yards of stone was made for the improvement of this place. The material was placed on the dam at the head of the island and a new dam built, shutting off a quantity of water escaping from the channel immediately above the shoal between the foot of the island and tow-head; this not proving sufficient, a second contract for 4,800 cubic yards was made later in the season. A short dam from the foot of the tow-head, and a low semicircular dam, 1,300 feet in length, opposite to it on the Ohio side, were built; this latter work had the desired effect of so confining the current that sand could

not be deposited. The effect of the improvement has been an increase of fully $1\frac{1}{2}$ feet in depth at all times, in low and moderate stages.

During the winter of 1867 and 1868 the new work on the old dam at the head of the island was seriously injured by the floods and ice; like the other dams it was built in a remarkably low-water season, and had not time to become packed with the gravel and sand which the ordinary floods deposit in such works, and which add so much to their tightness and strength. Fully a thousand cubic yards of stone, ranging in size from four to fifteen cubic feet each, were washed over into the deep pool below. This dam creates a fall of $4\frac{1}{2}$ to 5 feet before it begins to overflow; it appears that the apron, being about 12 feet of the top of the old dam left for that purpose, began to wash away with the great force of the water and ice piling upon it, moving stone after stone until the new material was reached, when it fell into the void, leaving the old dam on that part nearly as it had been. During the season of 1868 a third contract for 1,000 cubic yards was made and the breaks in this dam were thoroughly repaired. I had it leveled down somewhat in the central portions and stone broken in upon it, giving a longer slope on the lower side. During the progress of the last work it was greatly benefited by floods which deposited drift and light gravel upon it, so that it is believed that it has been permanently secured. The semicircular dam at the foot of the island was built higher on its lower half to prevent the strong overflow, which made it dangerous to tow-boats with their fleets. As generally desired by pilots, in 1869 this dam was carried to the same height all the way around. It was begun as an experiment, having been left low originally for tow-boats to run over at the higher stages, then built higher on the lower half in 1868 to prevent boats from being drawn over it. With ordinary care there is no danger now.

Good water from foot of Blennerhasset's to mouth of Little Hocking River, about one and three-fourths mile.

Little Hocking Bar, one hundred and ninety and three-fourths miles from Pittsburg.—In 1838, depth, 2 feet; length of channel, 2,500 feet; fall, 0.82 foot; rocks on right, gravel bar on left for some distance above Little Hocking, but the channel is of good depth, though crooked.

Good water to Newberry Bar, two and one-fourth miles.

Newberry Bar, one hundred and ninety-three miles from Pittsburg.—A large bar in the middle of the stream. In 1838, right channel, length, 1,225 feet; fall, 1.68 foot; width, 213 feet; depth, 22 inches; velocity, 2.81 miles an hour; area of cross section, 373.4 feet; flow, 89,494 cubic feet.

Left channel.—Length, 5,300 feet; fall, 2.61 feet; depth, 2 feet; velocity, 3 miles an hour; flow, 63,151 cubic feet; total flow, 152,655 cubic feet. The old channel was down the left or Virginia side. In 1844 a dam was partly built at the head from the left shore to the bar, which had a very good effect; at present the dam appears to be cutting at the island end. Along with the other place this dam should be repaired. To fill the gap, raise and finish the whole dam, will require 3,000 cubic yards of stone.

Good water to Mustapha Island, one and one-half mile.

Mustapha Island, one hundred and ninety-four and one-half miles from Pittsburg.—In 1838, channel (Ohio or right side) 2,600 feet in length; fall, 1.08 foot; depth, 30 inches. The old chart shows that in 1838, in the low stage, no water passed on the left side. It was never quite dry, and in coal-boat stages, or with, say, 8 feet water, the tow-boats now run the left channel, because it is shorter and straighter. There are

several large rocks on the left of this channel, at the head, complained of by tow-boat men. The current causes boats with their fleets to flank near them. Ultimately the necessities of this commerce will require their removal. The low-water channel down the right of the island was endangered by several rocks standing in good water, in close proximity to the channel, which show themselves at an extreme low-water stage. A contract for their removal (150 cubic yards) was made; the work has not yet been done, owing to high water, &c.

Hocking City, Ohio, one hundred and ninety-seven and one-half miles from Pittsburg.

Big Hocking River, one hundred and ninety-seven and one-half miles from Pittsburg.—Good water from Mustapha Island, passing Big Hocking River, to Belleville Bar, about three miles.

Belleville Bar, or Lee Creek Bar, one hundred and ninety-nine and three-fourths miles from Pittsburg.—In 1838, channel length, 7,500 feet; fall, 2.22 feet; width, 188 feet; depth, 2 feet; velocity, 2.51 miles an hour; area of cross sections, 362.1 feet. Rock bar on right; gravel bar on left. Channel rather crooked, but no particular trouble here. Improvement by means of dredging may be resorted to in the future. I have not considered it worth present notice in my estimates. Good water to Belleville Island, about two miles.

Belleville Island, two hundred and two miles from Pittsburg.—In 1838, channel length, 5,000 feet; fall, 4.60 feet; width, 297 feet; depth, 18 inches; velocity, 2.91 miles an hour; area of cross section, 685.4 feet; flow, 162,047 cubic feet. A dam was built in 1844 from the left or Virginia shore to the head of island; another, beginning at lower shoulder of head of island, across a slough, over to middle bar. This middle bar connected with a small bar at its foot by a third short dam, which shuts off a good deal of water that formerly ran between these two bars. These dams were intended to turn all the water, in a moderate stage, down Ohio shore. The chart exhibits only the lower-end dam. The extreme lower point of the series of dams has been cutting out and dividing the water, threatening to make a difficult place. A contract for the repairs of this and the general line of lower dams was made late in the season of 1868 for 3,500 cubic yards of stone. The contract was completed in 1869. Good water from Belleville Island to De Witt's Bar, below Shade River bend, seven and a half miles.

De Witt's Bar, two hundred and nine and one-half miles from Pittsburg.—In 1838, length of channel, 1,650 feet; fall, 1.39 foot; depth, 30 inches. Rock bar on right; gravel bar on left. It is not difficult to navigate this channel, but it is a bad place when boats get out of the channel. Good water to Swan Bar, two and a half miles.

Swan Bar, two hundred and twelve miles from Pittsburg.—In 1838, length of channel, 5,200 feet; fall, 1.68 foot; depth, 22 inches. Swan Bar becomes dry at about six feet channel on Ohio side. No trouble.

Good water to Buffington Island, two and one-fourth miles.

Gosling Island Bar, two hundred and thirteen miles from Pittsburg. A fine gravel bar on left. No obstructions to navigation. Rocky on right.

Buffington Island Head, two hundred and fourteen and one-fourth miles from Pittsburg.—In 1838, right channel, 2,250 feet; fall, 1.11 foot; width, 167 feet; depth, 22 inches; velocity, 1.61 mile an hour.

Middle channel.—Area, 2,505 feet; flow, 35,270 cubic feet; depth, 14 inches.

Foot channel.—Length, 1,650 feet; fall, 1.82 foot; depth, 18 inches; velocity, 1.81 mile an hour.

Head channel.—Left depth, ten inches.

Foot left channel, one and three-fourths miles from head of Buffington Island, and two hundred and sixteen miles from Pittsburg.—Left channel, 4,080 feet; fall, 1.14 foot; width, 741 feet; depth, 18 inches; velocity, 1.61 mile an hour; area of cross section, 750.2 feet; flow, 126.042 cubic feet per minute; total flow in the two channels, 151.312 cubic feet per minute. Captain Sanders did a great deal of work for the improvement of this troublesome place. He no doubt intended to make the channel down the Virginia side, which has the whole natural width of the river, while the Ohio chute is very narrow, even for single boats, such as were required to be accommodated in 1844. He began the construction of a long wing-dam down from the Virginia shore opposite the head of the island, which was carried six hundred feet down, when the work at that place was stopped. About 1,800 feet below he began another dam, leaving the Virginia shore, which circled out nearly to mid-river, and thence down, coming into the shore below Swan Creek, a whole length of 4,000 feet. Unfortunately, this work failed to make the depth, either on the upper or lower shoals, within six inches as good as that presented in the narrow Ohio chute. There was not enough water for two channels, and the appropriation was expended before he could get the Ohio chute closed. The work, therefore, proved of no benefit to low-water navigation. Early in 1867 a contract for 4,000 cubic yards of stone was made, which, together with seven other points above on the river, which were let before I could see the places in low water. Work was immediately begun, closing the Ohio chute. A difficulty in the case here was, that in closing this side we were compelling boats to leave a channel universally known to be, shoal as it was, six inches deeper naturally than the broad channel on the opposite side; so that, in reality, six inches of improvement would be nothing more than a transfer, with, however, an improvement in reducing the bad spots to one or two places; whereas, it had been troublesome in the Ohio chute for fully a mile, causing boats often to lose days and even weeks of time spurring and lightening over.

After a low-water examination, the contract was so evidently small, that a second one was made for 5,200 cubic yards additional stone, all of which was used in the construction of the Ohio chute dam and the repair of the upper half of Captain Sanders's lower dam. There was, then, a marked improvement in the navigation; the upper shoal, lying in a manner between the two dams, had a foot better water on it. The lower shoal was improved nine inches in depth, being therefore three inches better water than in the old channel. The channel across the lower shoal is quite crooked, and being comparatively new to most pilots, gave a great deal of trouble, and some complaints were made.

During the winter of 1867 and '68, the dam closing the Ohio chute, the lower half of which was unavoidably built on soft gravel, settled and allowed a large volume of water to escape from the channel. A contract for the repair of this place, as also to build a spur-dam to connect the Virginia chute dam with a bar which divided the water at the lower shoal, was made for 3,000 cubic yards of stone. About 2,200 cubic yards of this were put in before the winter of 1868-'69 set in, and during 1869 the contract was closed.

There was made, also, at the same time, a contract for 1,000 cubic yards of excavation, to straighten the channel through the shoal; but the season of 1868 was not favorable for commencing work. During 1869 a supplementary contract, for 2,500 cubic yards of dredging, was made for this place, and the work done. The channel at the lower

crossing was materially straightened, and the dams remain intact. This season no special trouble to navigation at Buffington will likely ensue. The dams being mostly new, may require some attention for several years, to make up the loss caused by their settling so much in the gravel.

Good water to Sand Creek Bar, three and a half miles.

Sand Creek Bar, two hundred and nineteen and a half miles from Pittsburg.—In 1838, channel 2,300 feet; fall, 3.65 feet; depth, 20 inches; velocity, 3 miles an hour. A dam was proposed at Sand Creek Bar, but no work was done. No water takes the chute at a low-water stage that this dam was proposed to close, so that its present construction is not deemed necessary. The water is quite shoal at the foot of this bar, where there are two channels, one down the middle, the other close to the Virginia shore. With Buffington channel improved, work will be necessary at this point, and, in connection with a general system of improvement, 2,000 cubic yards of dredging in the low-water channel at this place, seem all that is required to make good low-water navigation. The material excavation from one channel can be advantageously disposed of by filling into the other chute.

Good water to Old Town Bar, three and a half miles. A ledge of rocks for about two miles in length below Sand Creek Bar, on the Virginia shore, shows at 9 feet stage, but good water in channel opposite.

Old Town Bar, two hundred and thirty-three miles from Pittsburg.—In 1838, channel 2,150 feet; fall, 1.03 foot; depth, 26 inches. No trouble here.

Old Town Tow-head.—In 1838, channel 1,000 feet long; fall, 0.60 foot; depth, 36 inches; velocity, 2.21 miles an hour. No trouble here.

Good water to Goose Island Bar, two and a half miles.

Goose Island, head, two hundred and twenty-seven miles from Pittsburg.—In 1838, channel 1,250 feet long; fall, 1.12 foot; width, 232 feet; depth, 36 inches; velocity, 3.21 miles an hour.

Goose Island, foot.—In 1838, channel 2,850 feet; fall, 1.51 foot; depth, 27 inches. Tow-boats run to the left or Virginia side of the bar at the foot of the island. No trouble to tow-boating. The low-water channel has a pretty sharp turn, going down to right of the bar. A dam was proposed here, as marked on the old chart, but no work was done. The chart exhibits the shape of the channel here very correctly, and Captain Sanders's plan for the improvement of the place seems to be the best. It is to shut off the present low-water channel by a dam about 2,200 feet long, so as to confine all the water in the channel to the left of the lower bar, dry at a 4-foot stage, which is the course at present run, at a tow-boat stage. A little dredging may be necessary opposite foot of lower island, the quantity of which cannot safely be estimated until the effect of the dam is seen; this dam, though quite long, can be securely built with 2,200 cubic yards of stone.

Good water to head of Letart's Island, five miles.

Letart's Island, head, two hundred and thirty-two miles from Pittsburg.—In 1838, channel 712 feet long; fall, 0.47 foot; depth, 17 inches; velocity, 2.21 miles an hour.

Letart's Island, foot.—Length of channel, 2,000 feet; fall, 0.99 foot; depth, 27 inches.

Foot of lower island.—Length of channel, 1,440 feet; fall, 0.53 foot; depth, 30 inches. A dam was built in 1844 from the Virginia shore to head of the upper of the two islands. A considerable quantity of water runs through and over this dam, which, if directed into the right channel, would benefit the shoal place or the crossing at the foot of the lower island. A dam was also proposed at this lower crossing, but no work

was done. As there are two channels here, of course, if one were closed, it would benefit extreme low-water navigation in the other; adding to the extreme depth that might be caused by the completion of the dam at the head. With the improvements suggested above, the repair of the upper dam, and the construction of the jetty below from the foot of the upper island, appears to be necessary for the proper improvement of this place; 3,000 cubic yards of stone will be required, 1,000 of which should be applied to the repairs of the upper work, and 2,000 cubic yards below. In addition, a few large boulders and loose rocks should be removed from the right side of the channel opposite the lower end of the work, not of sufficient special importance to need a separate estimate at this time.

Good water to Letart's Falls, nearly a mile.

Letart's Falls, two hundred and thirty-four miles from Pittsburg.—In 1838, channel 2,800 feet long; fall, 3.15 feet, (rate of about 6 feet per mile;) depth, 24 inches; velocity, 3.81 miles an hour. Hard rock bottom. Very good water in the channel through these falls, except that in high water some boats have to warp up against the current, and in extreme low water nearly all boats that can then run have to warp here. In connection with a low-water plan of improvement, no dams could be placed to slacken the current here which would not seriously interfere with the safety of the tow-boat business. Accordingly I present no estimates for work.

Letart's Falls is the point where the surveys of Captain Sanders were suspended for the season, October 2, 1838. Coal-boatmen after passing Letart's Falls, going down stream, generally consider all comparatively clear when there is a good coal-boat stage.

Good water to Weaver's Bar, one mile.

Weaver's Bar, or Raush's Bar, two hundred and thirty-five miles from Pittsburg.—Depth of low water, 1838, 24 inches. No trouble here.

Good water to Wolf's Bar, two miles.

Wolf's Bar, two hundred and forty miles from Pittsburg.—Depth of low water of 1838, 26 inches. Wolf's is a high gravel bar, on the Virginia side, which comes out at 6 feet. There is no particular difficulty except that there is at the foot, in extreme low water, a shoal. This shoal was quite troublesome during the summer of 1868. The space is too contracted to admit of the location of wing-dams, but as the shoal is short, the removal of 1,000 cubic yards of gravel would be of benefit to the low-water navigation. Near the shoal, approaching from above on the right, there are a number of loose rocks; they are not very seriously in the way, but have been struck several times by pilots. Their removal should be accomplished at the same time that the dredging is done.

Siegrist's Ripple, two hundred and forty-two miles from Pittsburg.—Depth of low water of 1838, 30 inches; good water in channel; rock bar on right, gravel bar on left; a dangerous place for boats to run out of the channel, but it is easily run, and an accident here is usually only the result of carelessness on running in fog, &c.

Good water to Sliding Hill Bar, two miles.

Sliding Hill Bar, two hundred and forty-four miles from Pittsburg.—There is a sharp right-angle bend in the river to the right at Sliding Hill. Tow-boats here need careful pilotage, (as at Shade River Bend.) The channel, however, is broad and easy enough when run carefully.

Good water to Eight Mile Island, eleven miles.

Leading Creek, two hundred and fifty-two miles from Pittsburg.—Depth of low water of 1838, 48 inches; some rocks on left of channel a little above mouth of creek; not dangerous. Good, deep water all along here.

Eight-Mile Island, two hundred and fifty-five miles from Pittsburg.—Depth of low water of 1838, 24 inches; channel good along the right or Ohio side, except at the foot, where it gets quite shoal at extreme low water. No water runs along left side in extreme low water; so that a dam at the head would be of no benefit there. Since 1844, the channel has shifted closer to the Ohio shore than is shown on the old chart, and more of an opportunity is given for the improvement of this place. It is proposed to build a low dam which will not interfere with tow-boating, quartering downward from the left shore bar, commencing about 1,000 feet below the foot of the island, so as to contract the current somewhat. This dam will be about 1,000 feet long and will require 2,000 cubic yards of stone. Good water from Eight-Mile Island to Six-Mile Island, three miles.

Six-Mile Island, two hundred and fifty-eight miles from Pittsburg.—Depth of low water of 1838, 32 inches. This island has for many years been grown up and united with the main island, Virginia side. Except when the river is very high, (running over low banks,) no water runs around it. Gravel bar on both sides of the channel, which is always good. Good water to Kanawha Bar, (three-fourths mile below the mouth of Kanawha River,) six miles.

Point Pleasant, Virginia, two hundred and sixty-three miles from Pittsburg.

Kanawha River, Virginia, two hundred and sixty-three and one-half miles from Pittsburg.—Depth of low water of 1838, 26 inches. Point Pleasant is situated just above mouth of the river. Kanawha River has been improved by stone dams and walls. Steamers run up sixty miles to Charlestown, and sometimes forty miles farther. Good water in Ohio River, which is nearly straight, and about 1,100 feet wide along here, though, as shown on the chart, the low-water channel is quite narrow at one point, on account of some loose rocks and boulders. In case of a general improvement of the river, I would recommend the removal of 200 cubic yards of rocks at this point.

Kanawha Bar, two hundred and sixty-four and one-half miles from Pittsburg.—Depth of low water of 1838, 24 inches. Kanawha Bar becomes quite shoal in extreme low water, but there is no trouble when boats navigate other places. The channel runs pretty close to the Ohio shore. Good water, and river 1,200 feet wide, down to head of Gallipolis Island, about two and one-half miles from Kanawha River.

Gallipolis Island, two hundred and sixty-six miles from Pittsburg.—Depth of low water of 1838, 26 inches; main channel is down left or Virginia side. It is a little crooked at the foot; water good at all times. Very little water runs down the right or Ohio chute, although it is marked on the chart as an alternate channel; it is never run in low water. Good water to Carrion Ripple, five miles.

Carrion Ripple, (marked "Clarion" on old chart,) two hundred and seventy miles from Pittsburg.—An extensive rock bar extends from the right or Ohio side nearly over to the opposite shore, leaving a comparatively narrow but deep channel.

Two hundred and seventy-one miles from Pittsburg.—[The charts I have of Mr. Fuller's survey, of 1844, end here. In my first general report, the distances below this point were estimated according to our best judgment, while making a reconnoissance of the river in September and October, 1866, assisted by the memory of pilots. Having now completed our surveys, I present distances below this point accurately, as measured along the right bank of the river. The Government surveys, beginning at Clipper Mills, 271 miles from Pittsburg, under Sigismund Löw,

assistant United States civil engineers, were started July 1, 1867, and the survey of the upper division, extending to Cincinnati, 466½ miles from Pittsburg, was completed October 10, 1867.] Good water from Carrion Ripple to Raccoon Island, two miles.

Raccoon Island, two hundred and seven-three miles from Pittsburg.—Depth of low water of 1838, 18 inches; right channel at head, 18 inches deep; left channel at head, 15 inches deep; length of ripple, 6,532 feet; fall, 2.1 feet. Captain Sanders proposed a dam across the left or Virginia channel. A dam was partly built in 1844, but it is across the right or Ohio side, changing the channel. The present channel, on the Virginia side, is no deeper than the old one, and is more crooked, and more difficult to run in low water. Tow-boats can, however, run straight down in a coal-boat stage.

A good mark is very much desired by pilots going into this island channel at the head.

I have estimated 3,000 cubic yards to thoroughly rebuild the old dam. Some dredging at head and foot, to straighten the channel for very low-water boating, may afterward be advisable. Mr. Löw suggests a plan to remove the Ohio chute dam, and close the left or present chute; he says a large amount of dredging would be necessary at foot of island. Probably a more direct channel could be made in this way, but it would be rather narrow for coal fleets, while the large extra expense would seem to work against the present adoption of such a plan.

Good water from Raccoon Island to Straight Ripple, about nine miles.

Straight Ripple, two hundred and eighty-two and a half miles from Pittsburg.—Depth of low water of 1838, 22 inches; length of ripple, 3,200 feet; fall, 1.3 foot; 22 inches in low water. Rock bar on left; gravel bar on right; channel good; no work required here at present.

Good water to Little Guyandotte River, two and a half miles.

Little Guyandotte River, Virginia, two hundred and eighty-five miles from Pittsburg.—No trouble here, although there are a number of rocks, &c., below the mouth of Little Guyandotte and in the "reach" below for two miles. Rocks and movable obstructions, which should be taken out in case of a general improvement of the river. I would estimate this work to cost in all \$2,000.

Good water to Greenbottom Ripple, five and a quarter miles.

Greenbottom Ripple, two hundred and ninety and a quarter miles from Pittsburg.—Depth of low water of 1838, 18 inches. Short ripple, length of ripple, 7,000 feet; fall, 1 foot; channel close into Virginia or left side. Chain of rocks across from the Ohio side; gravel bar on left; channel is narrow and crooked; it might be somewhat improved by scraping, making it wider at the head. Captain Sanders proposed to cut through the bar to carry the channel nearer to the right or Ohio shore, but a more economical plan would be to straighten the present left channel, taking off the points of the bars; 1,000 cubic yards may be all that is necessary in case work is done generally along the river. Mr. Löw proposes a dam to be thrown from the Virginia shore, 900 feet above Shoal Run, to concentrate the water; such a dam would have a bad effect at a low coal-boat stage, throwing boats against the upper rock bar on the right.

That dam, with Captain Sanders's proposed dredging through the rocky bar, so as to make the channel close down the Ohio shore, would make an effective improvement. The first and simplest plan (scraping off the points of the bars) will doubtless, however, serve the purpose.

Good water to Dogham Bar, eight and three-quarters miles from Greenbottom Ripple.

Dogham Bar, two hundred and ninety-nine miles from Pittsburg.—Depth of low water of 1838, 24 inches; length of ripple, 2,800 feet; fall, 0.4 inch. This is a shoal for about half a mile in length, but never less than 2 feet water, even when there were but 17 inches at Guyandotte Bar. The channel is near the Ohio shore, a little curved but not difficult. There is a rough bottom of loose stone, many of which were removed in 1844. Here, and at other bars and shoals for 50 miles below, navigation becomes troublesome only at low water, on account of having to adhere so closely to the channel. Generally, on these 50 miles the navigation is good enough.

Good water from Dogham Bar to Big Guyandotte Bar, four miles.

Big Guyandotte, three hundred and three miles from Pittsburg.—Depth of low water of 1838, 24 inches; length of ripple, 7,320 feet; fall, 2.4 feet; depth of channel at head, 18 inches; at middle, or off the town of Proctorville, Ohio, 30 inches. Guyandotte Bar, at extreme low water, is a long, continuous shoal. Rock bar on left; gravel bar on right; channel of good width, straight between. At extreme low water it causes much trouble. To improve it essentially would require pretty extensive wing-dams. It is a wide, ugly place, with sometimes only 17 inches water. Mr. Löw proposes the construction of spier-dams, not less than three from each side of the river, and, perhaps, dredging between. The only dam I would recommend at present, however, is one shown in red on the chart near the head of the shoal on the left. It will be about 2,500 feet long, and to turn all the water at a four-foot stage will require 5,500 cubic yards of stone. This dam will greatly benefit the worst part of the shoal, and will not interfere with the landing at Guyandotte, as it ends, just above the nook that boats are compelled to take to reach the landing at low water. Should this not prove to be all that is needful, several short dams, as proposed by Mr. Löw, might be constructed.

Nine Mile Reach begins 304 miles from Pittsburg.

Symms's Creek Bar, three hundred and six and a quarter miles from Pittsburg.—Ohio side no difficulty. At 308 miles Fuller's surveys ended, 1844, but we have no record of them below the 271 miles at Clipper Mills.

Buffalo Creek, three hundred and eight and one-half miles from Pittsburg.

Burlington Bar, (or Twelve Pole Bar,) three hundred and twelve miles from Pittsburg.—Length of ripple, 6,350 feet; fall, 1.0 foot; depth of low water of 1838, 18 inches; below mouth of Twelve Pole Creek the channel is down Ohio side, except at extreme low water, when it crosses out to middle of river, and back again under foot of bar. This place is fully as troublesome as Guyandotte, and should be improved with it. It is proposed to carry a low wing-dam from the Virginia shore across the old low-water channel, ending on the low bar, which divides the two channels at the head. This plan will permanently secure the Ohio channel as good a depth as the other improved shoals. The dam will be about 2,500 feet long, and will require 5,000 cubic yards of stone. Mr. Löw, besides this dam, recommends another from the same side farther down the shore. At present, however, the construction of the additional dam is not deemed necessary.

Big Sandy Shoals, three hundred and fifteen miles from Pittsburg.—Depth of low water of 1838, 23 inches.

Big Sandy Shoals, head.—Always good water in this shoal, but a rough, rocky bottom; many obstructions. This shoal extends from one mile above Big Sandy to three miles below Catlettsburg, Kentucky,

about four miles altogether. Throughout this distance there are a number of rocks, greatly in the way of boats at low water. They are frequently struck. Captain Sanders did some work here removing them. Our charts do not show the location of particular rocks which should be removed, but in connection with a general improvement, \$3,000 could be advantageously expended on the river here in improving the low-water channel. All these obstructions are covered, and not in the way at a coal-boat stage.

Big Sandy River, three hundred and fourteen and one-half miles from Pittsburg.—Line between Virginia and Kentucky.

Catlettsburg, Kentucky, three hundred and fourteen and one-half miles from Pittsburg.—At mouth of Big Sandy.

Good water for three miles from foot of Big Sandy Shoals.

Poag's Shoals, or Ice Creek, three hundred and twenty-two miles from Pittsburg.—Plenty of water, but there are rocks which should be taken out for the improvement of low-water navigation.

From a point 21 miles above Poag's Shoals to Burk's Point, 25 miles below, making a distance of 46 miles, a general clearing out of loose rock is urgently needed. Some of the rocks contain ten cubic yards each, in five feet water, requiring blasting. A crane boat and flats may be used here to advantage. Some of this sort of work was done in 1844, under Captain Sanders, by Captain Hiram Birch, at this place, Dogham Bar, Guyardotte, and Sandy Shallows. In my annual report for the year ending June, 1867, I recommended \$17,000 for the whole distance.

Storm's Creek Shoals, three hundred and twenty-five and one-half miles from Pittsburg.—Depth of low water 1838, 24 inches; good water, rock ledges, troublesome only in low water.

Ferguson's Bar, two hundred and twenty-nine and one-half miles from Pittsburg.—Depth of low water of 1838, 34 inches. Good channel depth, high gravel bar on left, dry at nine feet.

Good water from Ferguson's Bar to Greenup's Shoal, one mile.

Greenup's Shoals, three hundred and thirty and one-half miles from Pittsburg.—Depth of water of 1832, 18 inches.

Greenup's Shoals, head.—The first crossing at the head of these shoals would be improved by removing some of the rocks. Long shoals, full of rocks all the way. On this account, they have to be navigated with great care at extreme low water.

Good water from Greenupsburg to Jenalt's Shoal, three miles.

Jenalt's Shoals, three hundred and thirty-six miles from Pittsburg.—Depth of low water of 1838, 23 inches. Rocky bars both sides; rough, hard bottom; channel of average width; not difficult.

Burke's Point, three hundred and forty-six and one-half miles from Pittsburg.—Good water to this point. This is the lower end of what is commonly considered the bad part of the river for forty or fifty miles above; excepting rubbish, (elsewhere noticed,) there is no difficulty at this place.

Good water to Little Scioto Bar (a half mile above Little Scioto River,) five miles.

Little Scioto Bar, three hundred and forty-six miles from Pittsburg.—A ledge of rocks from right side extends from the head down a little below the mouth of the river, throwing the current over to the Kentucky shore. From the foot of the rocks on the right a sand-bar continues on the left down one-fourth mile to the head of a second rocky ledge on the right. The channel has thus three crossings, but the best water all runs in one place and there is no particular trouble.

Good water to Tiger Creek, five miles.

Tiger Creek, Kentucky, three hundred and fifty-one miles from Pittsburg.—The only difficulty along here arises from wrecks, rubbish, &c. Depth in low water of 1838, 30 inches.

Good water to mouth of Big Scioto River, three miles.

Big Scioto River, three hundred and fifty-four miles from Pittsburg.—Very high gravel and sand bar below the mouth of river on the right; also a high gravel and sand bar on the left. Channel bends close in to the Ohio shore below the first bar mentioned, continuing down that shore to the old mouth of the river.

Good water from old mouth of river and below; although rather shoal, it gives an easy channel to Turkey Creek Bar, five miles.

Turkey Creek Bar, three hundred and fifty-nine miles from Pittsburg.—Depth of low water of 1838, 36 inches. Gravel-bar on right; channel near the Kentucky shore; bar high all around the point of Truman's Bottom as far down as Scaffold Lick Creek, Kentucky, three and one-half miles; channel keeps pretty close to the Ohio shore all around this place.

Conconneque Creek Bar, three hundred and sixty-five miles from Pittsburg.—Depth of low water of 1838, 20 inches. Gravel-bar on both sides; at the head of channel rather crooked between the two, crossing over to Kentucky shore below mouth of creek, and continues along Kentucky shore for one and one-half miles; shoal, but good navigation.

Twin Creeks, three hundred and seventy and one-half miles from Pittsburg.—Depth of low water of 1838, 24 inches. High gravel-bars at the mouth, which throw the channel close in to the Kentucky shore at the head; it then crosses back in to Ohio shore at Buena Vista, (a landing,) to avoid a sand-bar on the left.

Good, deep river down to Quick's Run, Kentucky, eight and one-half miles.

Quick's Run, Kentucky, three hundred and seventy-nine miles from Pittsburg.—Depth of low water of 1838, 24 inches. Main bar on right; small bar at mouth of creek on the opposite side. At extreme low water the channel, which here turns over to the Kentucky shore, gets quite shoal. The place could be improved by a wing-dam running from Ohio shore to head of main bar. This dam, as shown in red on the chart, crosses out to beyond the middle of the river, to cut off a large quantity of water escaping through a narrow chute below. Whole length about 2,000 feet, and will require about 5,500 cubic yards of stone. Quick's Run is often quite troublesome, and, with the general improvement of the river, work will certainly be necessary. Another dam has been proposed to shut off the water from the left channel, but as these channels are alternately good the dam proposed above will act beneficially on both, leaving either one, as the case may be, better than the other.

Lower crossing of this bar comes in to Ohio shore one-fourth mile above Rome, Ohio, and one mile below Quick's Run, three hundred and eighty miles from Pittsburg.

Stout's Run, three hundred and eighty-one and one-half miles from Pittsburg.—To avoid a bar on Ohio side at mouth of Stout's Run, the channel crosses over to Kentucky shore; follows Kentucky shore to Graham's Lower Station Bar, one mile below Stout's Run, and three hundred and eighty-two and one-half miles from Pittsburg. Depth of low water of 1838, 24 inches. Thence crosses between sand-bar on right and rock on left. Easy channel between them.

Brush Creek Island, three hundred and eighty-four and one-half miles

from Pittsburg.—Depth of low water of 1838, 24 inches; length of ripple, 5,270 feet; fall, 1.8 foot. Brush Creek Island head-dam at the head partly built in 1844 from Kentucky side to Brush Creek Island. Work was not far enough advanced to do much good; now, at extreme low water, it gets quite shoal. This is the last point on the river where Captain Sanders did any work upon riprap dams. The dam partially constructed would have, when finished, a whole length of 4,000 feet, and will require 9,000 to 10,000 cubic yards of stone to thoroughly rebuild it now. As it is shown on the map, in red, an entirely new dam, leaving the Virginia shore some distance below the old work, with a whole length of about 3,000 feet, has been planned, which would require about 6,000 cubic yards of stone. A dam, to shut off the water here, is already greatly needed for the improvement of navigation.

Pennycail's Bar, three hundred and eighty-eight and one-half miles from Pittsburg.—Large gravel bar on left or Kentucky side throws channel close to Ohio shore. No trouble at this crossing.

Manchester Island, three hundred and ninety-two miles from Pittsburg.—Depth of low water of 1838, 18 inches; nearly two miles long; channel, Kentucky side, close to main shore; sand often accumulates in channel both along the island and at the foot. Below foot of island channel crosses over to Ohio side to wharf boat at Manchester town. In extreme low stages no water passes down the right side; a dam at its head would therefore be of no benefit in extreme low water, and at no other time is there any trouble. A dam as shown on the chart, to shut off the right channel where there is a division of the water around a small bar dry at a two-and-one-half-foot stage, will keep the channel permanently down the Kentucky shore. This seems to be the only alternative here. This dam will require 7,000 cubic yards of stone. It has been proposed to open up the right side of the island, but such work would be costly, and would be no better or more free of sand complained of. The plan proposed should be one of the first worked upon in the event of an improvement of this part of the river. In my annual report for the year ending June, 1867, it was thought that the removal of a number of wrecks, which had collected the sand, would accomplish all the desired improvement at this place. I am satisfied now, since making our more careful survey, that nothing but a dam will radically improve the low-water navigation at this point.

Deep water in channel to Brooks's Bar, ten and one-fourth miles.

Brooks's Bar head, four hundred and two and one-fourth miles from Pittsburg.—Depth of low water of 1838, 30 inches. Large gravel bar in middle of river; no particular trouble.

Good water to Charleston Bar, nine miles.

Charleston Bar, four hundred and eleven and one-fourth miles from Pittsburg.—Depth of low water of 1838, 21 inches. Length of ripple, 7,085 feet; fall, 1.4 foot. A large gravel and sand-bar in the middle of the river; channel usually on the right side, but at extreme low water it takes down the left. At the lower stage two channels are presented at the foot of the main left channel, one taking around foot of big bar to the Ohio shore on the right, the other running to Kentucky shore. Usually the last-mentioned holds out longest in low water. There is no doubt that the right channel is the most natural one, and if the left chute were entirely closed at the head by a dam, as is shown on the chart, it would always be easily navigated. This dam would pass through shoal water, and would be about 2,200 feet long; it will require 5,500 cubic yards of stone. It is not likely that this dam would settle greatly, though it would pass over a sandy bottom on which there is

but little current. Mr. Low recommends this dam, and it seems the only practicable plan for a low-water improvement. Charleston Bar is frequently as shoal as the worst places along this part of the river.

Good water to Dover, Kentucky, five and one-half miles.

Dover Bar, four hundred and forty-six and one-half miles from Pittsburg.—Large sand-bar extending to middle of river; channel deep. The channel makes a long crossing to Kentucky shore into the head of Straight Creek Bar.

Straight Creek Bar, four hundred and eighteen and one-half miles from Pittsburg.—Depth of low water of 1838, 38 inches. Two miles below Dover a fine gravel shore. The channel is at foot of the bar, close in to the Kentucky shore. River is straight along here for several miles; course nearly west.

Good water to extreme lower end of Augusta Bar, seven and one-half miles.

Augusta Bar, four hundred and twenty-five miles from Pittsburg.—Depth of water of 1838, 21 inches; length of ripple, 11,900 feet; fall, 1.3 foot. The channel shifts in the sand, though generally it runs out into the middle at the foot of the bar. This bar begins at Augusta, and covers two-thirds width of river for two miles down. The highest part comes out at 4 feet.

There is often great difficulty experienced during low water at the foot of the bar; sand accumulates, and the channel route over the shoal shifts. A dam, as shown on the chart, to extend out from near the foot of the left shore bar, so as to confine the water more to the Kentucky shore, seems advisable. In case this dam does not act properly it should be carried down several hundred feet further, so as to cross one of the channels. The necessity for this addition cannot be determined until the proposed work is done. The portion to be built at first will be not less than 3,000 feet long. gravel bottom for the greater part of the way; but being through comparatively shoal water, it will not require more than 6,500 cubic yards. The addition or extension mentioned may require 2,500 cubic yards more.

Good water to Bull Skin Creek, three miles.

Bull Skin Creek, four hundred and twenty-eight miles from Pittsburg.—Here channel crosses to Kentucky shore, and is generally rather shoal (not deep) without being shallow.

Locust Bar, four hundred and twenty-nine and one-half miles from Pittsburg.—Depth of low water of 1838, 32 inches; length of ripple, 9,200 feet; fall, 0.8 foot.

Locust Creek Bar.—Channel turns over to Ohio shore to avoid gravel bar below mouth of creek and keeps that side to upper end of Chilo. No trouble at this crossing. From foot of Locust Bar to Chilo one mile. Channel much obstructed with logs, sunken boats, &c., and much damage has been done to boats, especially at one place, about a fourth of a mile above Chilo.

Chilo Bar, four hundred and thirty-one miles from Pittsburg.—Depth of low water of 1838, 36 inches. Chilo Bar, (formerly Mechanicsburg,) below Chilo, a large bar on Ohio side; channel here very shallow; in 1838 only 13 inches deep at one time, although the old report shows 36 inches. At Chilo channel crosses to Kentucky shore; a general shoal all through this reach.

Channel keeps Kentucky shore to Big Snag Creek.

Snag Bar, four hundred and thirty-one and three-fourths miles from Pittsburg.—Depth of low water of 1838, 18 inches; length of ripple, 11,000 feet; fall, 1.11 foot. Channel crosses here to Ohio shore; at ex-

treme low water it is troublesome. No improvement was ever attempted here. This place cannot, however, be neglected in case of a general low-water improvement. I will propose a dam leaving the Kentucky shore about 800 feet below Big Snag Creek (shown on the chart) to extend into the river, circling downwards somewhat, 2,000 feet long, requiring 4,000 cubic yards of stone. This dam would have a good effect in holding up the water on the shoal, and would probably act beneficially on the Chilo crossing, one and one-half miles above. Throughout the Chiloe reach much good will be accomplished with the removal of wrecks and snags, which gather sand and make the channel difficult to run safely. This latter work will probably be done with another season's work upon the river with the snag-boats.

Good water to head of Richmond bar, twelve and one-half miles.

Richmond Bar Head, four hundred and forty-four and one-half miles from Pittsburg.—Depth of low water of 1838, 29 inches, middle 34 inches, foot 32 inches.

Richmond Bar.—The main channel here is down the right-hand shore, although the other channel, down left shore to the foot, then crossing over at the upper end of the town, is sometimes run. The Ohio or right channel is always navigable.

Good water to head of Nine-Mile Bar, seven and three-fourth miles.

Nine-Mile Bar, or Ship-yard Bar, four hundred and fifty-two miles from Pittsburg.—A mile and a half above the Ship-yard Bar the channel crosses over to Ohio side to avoid a high bar on the left around the point to Nine-Mile Bar, where it crosses back to the Kentucky shore, thence down to Eight-Mile Creek, then returning to Ohio side again. The channel through all this is, however, easy, and crossings not difficult.

Good water to head of Five-Mile Creek Bar three and one-half miles.

Five-Mile Creek Bar, four hundred and fifty-five and one-half miles from Pittsburg.—Depth of low water of 1838, 30 inches; channel at head turns over to Kentucky shore, then at its foot crosses back to Ohio shore below mouth of creek; here it crosses towards Kentucky shore again to take middle channel of Four-Mile Bar. This channel gets troublesome; the other close down the Ohio shore, when the water takes this channel, is better. Four-Mile Bar gives some trouble at extreme low water on account of shifting sands.

Four-Mile Creek Bar, four hundred and fifty-six and one-half miles from Pittsburg.—Depth of low water of 1838, 18 inches. In extreme low water gives much trouble. The crossing at head from Kentucky is the most troublesome on account of shifting sands. The shore chute gives most trouble at the mouth of Ohio Four-Mile Creek. Water below this is shoal with winding channel through to Kentucky shore at foot of the bar. As shown in red on the chart, it is proposed to construct a dam from the Kentucky shore, opposite lower end of the central bar; it will be about 2,300 feet long, and will require 5,500 cubic yards of stone. This dam will greatly benefit the worst part of the shoal.

Good water thence to Little Miami River, three and one fourth miles.

Little Miami River, four hundred and fifty-nine and three-fourths miles from Pittsburg.—Depth of low water of 1838, 24 inches. Columbia crossing a mile below. Channel crosses over to Ohio shore at the old town of Columbia, thence down the Ohio, or right shore, to head of Crawfish bar, one and a half miles.

Crawfish Bar, four hundred and sixty-two and one-half miles from Pittsburg.—Depth of low water of 1838, 20 inches. Plenty of water in channel along Ohio shore, leaving high sand and gravel bar on left.

Whetstone Creek Bar, four hundred and sixty-four miles from Pittsburg.—

Ohio Rock Bar at mouth, around which the channel bends, then back again to Ohio shore, down to Cincinnati, 3 miles below. Deep water down to Eureka dry docks. Thence to below Cincinnati it is a general shoal, though not shallow or troublesome.

Licking River, opposite Cincinnati, four hundred and sixty-six and one-half miles from Pittsburg.—Hard rock bottom off Licking River, extending out two-thirds across Ohio River. No trouble over it in the channels. [Mr. Low's upper division of surveys terminated at the suspension bridge, 466½ miles from Pittsburg, October 10, 1867, having surveyed the river from Clipper Mills, 271 miles from Pittsburg. From Cincinnati the surveys were commenced under Alonzo Livermore, esq., assistant United States civil engineer, July 3, 1867. Mr. Livermore leaving the following month to go on duty on the Mississippi, the surveys were continued by James E. Day, esq., assistant United States civil engineer, who completed them to Cloverport, Kentucky, 240 miles from Cincinnati, by the end of the season of 1867. Mr. Low, after reaching Cincinnati, passed down with the survey boat and party to Evansville, where he began his lower division, completing 43 miles below Evansville by the end of the season of 1867.]

City of Cincinnati, four hundred and sixty-six miles from Pittsburg.

Glasshouse Bar, four hundred and sixty-seven miles from Pittsburg, below suspension bridge, Cincinnati. Length of ripple, 3,938 feet; fall, 1.0 foot.

Cincinnati Glasshouse Bar, off Race street.—Two channels here, over a rock bar reaching across the river. First channel at the head crosses to Kentucky shore, thence wearing gradually into middle of river; second channel keeps Ohio shore opposite Western Row street, thence gradually wears into middle of river. Sometimes one channel is better than the other from shifting in current above, but no particular trouble when running in the channel. Good water to McCollom's Bar, four miles.

McCollom's Bar, four hundred and seventy-one miles from Pittsburg.—Depth of low water of 1838, 21 inches; length of ripple, 3,800 feet; fall, 1.9 foot. Two channels here—one down the Kentucky shore to head of large main bar, then crossing to Ohio shore between Picayune Bar on right and main bar on left; the other to the right of Picayune Bar, crossing into the same place as the first, close in to the Ohio shore, and thence down the Ohio shore to foot of the bar. At low water trouble is experienced from irregular cross currents. At low-water the channel is greatly confined, particularly at the mouth of the run, which has a small bar in front, which in avoiding frequently causes boats to strike on the main bar opposite. Fifteen hundred cubic yards of dredging here will add 50 feet to the channel width, and be a great relief to its navigation. Between McCollom's and North Bend, although there is shoal water, the channel is easy and pretty direct, eleven miles.

North Bend or Henderson's Bar, four hundred and eighty-two miles from Pittsburg.—Gravel bar on both sides; channel good depth between.

Good water to Bosley's or Medoc Bar, three miles.

Bosley's or Medoc Bar, four hundred and eighty-five miles from Pittsburg.—Length of ripple, 4,700 feet; fall, 0.5 foot. Two channels here; never both good at the same time in low water. Generally the channel on the Ohio side is the best, the one usually run. At extreme low water the channel often takes over to Kentucky shore, and down the left of the bar of sand and gravel, with soft bottom, which causes it to change so much. A wing-dam, 3,000 feet long, from the Kentucky shore, closing the Kentucky channel, will greatly improve the low-water

navigation. It is estimated that this dam will require 7,200 cubic yards of stone. Contract made in 1869, expected that it would be completed in 1870.

Good water to Big Miami River, two miles.

Big Miami River, four hundred and eighty-seven miles from Pittsburg.—Depth of low water of 1838, 24 inches; length of ripple, 4,800 feet; fall, 1.3 foot. Dividing line between Ohio and Indiana. Large gravel bars on both sides of the Ohio River; channel between has plenty of water. No trouble, excepting snags, &c., to be removed.

Lawrenceburg, Indiana, four hundred and eighty-nine miles from Pittsburg.—Occasionally, though rarely, sand accumulates below wharf-boat at Lawrenceburg, throwing channel toward Kentucky shore.

Good water to head of Loughery's Bar, five miles.

Loughery's Bar, four hundred and ninety-four and one-half miles from Pittsburg.—Length of ripple, 5,600 feet; fall, 1.1 foot. Very large gravel bar on left; small gravel bar on right, at the head, extending down to Loughery's Creek on the right; channel between bars. No trouble.

Loughery's Island, four hundred and ninety-seven and one-half miles from Pittsburg.—Four miles from Loughery's Bar. Depth of low water of 1838, 24 inches; length of ripple, 9,200 feet; fall, 1.7 foot. Regular channel down left side. At foot of island it divides, one crossing to Indiana or right shore, the other straight down nearest Kentucky shore. No trouble.

Good water down Kentucky shore to Rising Sun Bar, three and a half miles.

Rising Sun Bar, five hundred and one miles from Pittsburg.—Depth of low water of 1838, 24 inches; length of ripple, 8,100 feet; fall, 3.8 feet. Head of bar is a difficult shoal place; channel crosses close to right shore, continuing down that shore to the main landing (wharf-boat) at Rising Sun town; thence crosses abruptly to Kentucky shore under foot of the large bar. In low water the entire stream runs through this channel. The chart shows this difficult place very well; but as the soundings were taken at about a six-foot stage, when the sounding-boat could not reach every locality, the height of the main bar could not well be so clearly shown. This place has become more troublesome of late years than formerly. During a visit to the place in 1867 I saw parties plowing the bar in search of boulders, which work has been going on for years, and had the effect of spreading the water at the upper shoal at the expense of the channel depth. Several plans have been suggested for the improvement of this place. Leaving the present channel open, one plan requires 5,000 cubic yards of dredging at upper ripple, with the construction of a dam 2,200 feet long at foot, to back up the water in the lower shoal. This dam would either cross above a sandy bar, through which a great deal of water often cuts, or tail down from the foot of the main bar across the present channel, and would aid navigation. The latter plan would be less in the way of tows on floating boats at the higher stages. Either dam would require 5,500 cubic yards of stone. The gravel and boulders obtained above could be economically used at this point. These plans accord better with the general system which is recommended at points above. Between Cincinnati and Louisville the river business is so important that the material improvement of the bad points is urgently required. Another plan, involving a large amount of dredging, has been recommended; this plan proposes closing the present channel by a dam of gravel and stone to turn all the water at a six and a half foot stage into a channel dredged through the bar. The removal of 75,000 cubic yards, or perhaps much

less, it is surmised, would so start the current that it would continue to wash out to a natural straight shape. It will be observed that these are nooks extending from above and below the bar in the line of the proposed channel. This dredging might probably be accomplished at a cost of 75 cents per cubic yard. A large portion of the excavated material could be employed in banking the channel and giving permanent shape to the river below, benefiting navigation at Ranty's Shallows, &c. The town of Rising Sun would not be on the regular channel course, but boats in all ordinary seasons could run in there from below.

During 1869 a contract for 5,000 cubic yards of dredging, and 5,500 cubic yards of stone, was made for this place. During the winter following a considerable quantity of the stone was quarried, and the contractors are ready to begin boating the coming summer.

Ranty's Shallows, five hundred and three miles from Pittsburg.—Shoal, but not so shallow as to seriously interrupt navigation at present.

Good water thence to head of Gunpowder Creek Bar, seven miles.

Gunpowder Creek Bar, five hundred and nine miles from Pittsburg.—Depth of low water of 1838, 21 inches; length of ripple, 6,400 feet; fall, 2.2 feet. Channel runs down near Kentucky shore to near the creek; thence crosses out to within a third of the Indiana shore.

At foot of this bar two channels around a middle sand-bar, the main channel taking down the Indiana shore past the point. At extreme low water it often goes into the bend in the Kentucky shore to left of this sand-bar. The channel down the left should by all means be closed, as is indicated on the chart. The proposed dam will require about 9,000 cubic yards. The cost will be within the amount recommended in my annual report to the Department for the year ending June, 1867. No other work appears necessary for the improvement of this place.

Big Bone Lick and Tow Head, five hundred and twelve miles from Pittsburg.—Fifty miles below Cincinnati; channel on left of large bar. Rockley Ledge, at the head, makes out from Kentucky shore; gravel bar on right channel between; another ledge of rock from Kentucky shore at foot of bar. Channel crooked and narrow, but always plenty of water; never less than 30 inches, seldom under 3 feet. At seven-foot stage no water runs down the Indiana side of tow-head.

Good water to Warsaw Bar, twelve and a half miles, except one place at Potato Patch, one mile above Warsaw.

Sugar Creek Bend, five hundred and eighteen miles from Pittsburg.—At 518 to 520 miles hard bend in river to right; narrow but deep.

Potato Patch, five hundred and twenty-two miles from Pittsburg.—Channel here crosses in to near point above Warsaw. The bed of the river is lumpy, gravel piles, &c., but plenty of water in the channel. The name comes from a fancied resemblance to a vegetable garden. The terrible disaster to the packets United States and America occurred at this point, December, 1867.

Good water to head of Warsaw Bar, two and a half miles.

Warsaw Bar, five hundred and twenty-four and a half miles from Pittsburg.—Depth of low water of 1838, 21 inches. This is one of the most troublesome places between Cincinnati and Louisville. As shown on the chart, there are two channels at the head of this bar, and water escaping through chutes to the right of both of them. The best plan for the improvement of this place seems to be the construction of a wing-dam extending from the right-shore bar, below the Florence Landing, across to the lower side of the channel. This will leave both of the present channels open. This dam will require about 7,500 cubic yards of stone; 2,000 cubic yards of dredging in the right channel will be

necessary to be done after the construction of the dam. Mr. Fuller, in 1844, proposed dredging altogether. During 1869 contracts for the above quantities of stone and dredging were entered into, and the dam begun from the Indiana side before the winter set in. The river below Warsaw Bar is shoal at many places to Long Lick Creek, four miles, but not shallow enough to interfere with navigation.

Deep water from Log Lick Creek to Vevay Island, two and a half miles.

Vevay Island, five hundred and thirty-one miles from Pittsburg.—At head the channel is near left shore. All the water runs down the Kentucky side, although at one time boats in high water could run the Indiana or right chute; no work required.

Good water to head of Vevay Bar.

Vevay Bar, five hundred and thirty-three miles from Pittsburg.—Depth of low water of 1838, 24 inches. At the head of this bar channel crosses between two gravel bars close in to Indiana shore, and down that shore to near the foot; then wears out one-third into river; then back to same shore, a short distance above God's or Henry's Landing. No work will be required here until a very material improvement of Warsaw, Rising Sun, and other bad points shall have been effected. At present there appears no prospect of the place giving trouble.

Good water to head of Craig's Bar, four miles.

Craig's Bar, five hundred and thirty-seven miles from Pittsburg.—Depth of low water of 1838, 21 inches. Large bar on left. Here channel crosses between two gravel bars, close in to Indiana shore. Plenty of water in it. Continues down that shore to foot of bar, then crosses square over to Kentucky shore under the foot of main bar. This lower crossing is six inches shoaler than that above, and ultimately will require improvement. As shown on the chart, a wing-dam crossing the low bar on the right has been planned to hold up the water on the shoal; its good effect will no doubt be felt on the upper shoal, though that place is not likely to give trouble. Seven thousand cubic yards of stone will be necessary for the construction of a low dam at this point. The river is shoal, more or less, to mouth of Kentucky River, about six miles; but when the channel is kept there is no particular trouble.

Good water from Craig's Bar to Locust Creek Bar, seven miles.

Locust Creek Bar, five hundred and forty-four miles from Pittsburg.—Depth of low water of 1838, 24 inches. At the head, channel crosses from Kentucky toward Indiana shore as far as middle of river, then follows left-hand bar clear out to the foot. Plenty of water in channel.

Good water to Hoagland Bar, four miles.

Hoagland Bar, five hundred and fifty miles from Pittsburg.—Depth of low-water of 1838, 24 inches; channel close to Indiana shore until near foot of bar, then crosses out to near middle of river, then straightens down, continuing so to foot. Always plenty of water to Madison, Indiana; not shoal enough to give trouble.

Madison, Indiana, five hundred and fifty-three miles from Pittsburg.—From Madison to Cooper's Bar water is very deep in the channel, five miles.

Cooper's Bar, five hundred and fifty-eight miles from Pittsburg.—Depth of low water of 1838, 27 inches. At the head, gravel bars on both sides; channel between close in to Indiana side. Good water at all times. The left-hand bar is very large and high, of gravel and sand.

Good water in channel to Garrett's Landing, twelve miles.

Garrett's Landing, Kentucky, five hundred and seventy miles from Pittsburg.—Channel here leaves Kentucky shore and crosses to within one-

third of Indiana side, to avoid rocks and shoal-water in bend on the left. No trouble.

Good water in channel to Eighteen-Mile Island, seven and a half miles.

Eighteen-Mile Island, five hundred and seventy-seven and a half miles from Pittsburg.—Depth of low water of 1838, 24 inches. Channel down Indiana shore to near foot of island; then along crossing to Kentucky shore. The extreme low water becomes quite shoal sometimes, requiring good pilotage. The improvement of Grassy Flats Bar with a dam will probably benefit this place.

Good water to head of Grassy Flats Bar, four miles.

Grassy Flats Bar, five hundred and eighty-one miles from Pittsburg.—Depth of low water of 1838, 24 inches. Formerly, there were three channels here. The upper and left-hand channels were shut with pile wing-dams, erected, say, about 1828, by Captain H. M. Shreve. The channel now run crosses from Indiana to Kentucky shore, between two gravel bars, though sometimes the channel is close down the Indiana shore, to the right of all, as shown on the chart. Either of these channels could be greatly improved by means of a dam confining the entire river to one of them. A dam as proposed, closing the Indiana channel, would be about 3,000 feet long, and will require 9,000 cubic yards of stone. A dam closing the present and usually the best channel would be not less than 4,700 feet long, requiring 13,000 cubic yards of stone.

The Indiana channel is made quite narrow by bars at the mouths of the creeks, and, otherwise, does not present as favorable an appearance as the other channel. I would, therefore, recommend the closing of the Indiana chute.

Brevet Major General Weitzel, of the United States Engineer Corps, in charge of the improvement of the Louisville and Portland Canal, has proposed the construction of a dam at the head of the falls, to furnish water to the canal. It has been thought that a dam there, backing up three feet, would benefit the Grassy Flats Shoal; but it appears from our levels that the fall is 4.10 feet. A dam at the falls may slacken the water at Twelve-Mile Island, giving also an improved depth, though the place is not accounted at all troublesome.

Good water to head of Twelve-Mile Island, seven miles.

Twelve-Mile Island Head, five hundred and eighty-eight miles from Pittsburg.—Channel crosses in to near Indiana shore, between two gravel bars, thence down Indiana or right side of island. No trouble. Always plenty of water.

Six-Mile Island, five hundred and ninety-two miles from Pittsburg.—Channel runs down middle of river between these two islands.

Good deep water, and deep water to Louisville, six miles.

Louisville, Kentucky, five hundred and ninety-eight miles from Pittsburg.

Falls of Ohio, head, five hundred and ninety-nine miles from Pittsburg.—At Louisville, Kentucky boats can run the falls channel down stream when there is a depth of $2\frac{1}{2}$ feet. The usual up-channel can be passed at a six-foot stage; this is called the Kentucky chute. The main channel, or "Indiana chute," is run sometimes at five feet; the Indiana chute has a little better water, and is longer than the Kentucky chute. Elaborate surveys of the falls, &c., have been made under the direction of Brevet Major General Weitzel, United States Army, of the United States Engineers, in connection with the improvement of the navigation of these chutes, as well as the enlargement of the Louisville and Portland Canal, and the surveys for a canal on the Indiana side. The improvement of this difficult part of the river has been allotted by the Government as a special work, under charge of experienced engineers, who

could give that constant and personal attention required by the importance of the case. Through the courtesy of General Weitzel this office has been put in possession of a valuable map of the falls, which has been reduced in scale to correspond with our Ohio River charts, so that no break occurs in the distance, profiles, &c. The Department is doubtless well acquainted with the features of this place, and can judge of the character of work recommended for the improvement of navigation from the reports of the officers in charge.

Sand Island, above Portland, Kentucky, six hundred and one and one-half miles from Pittsburg.—Below the falls of the Ohio, which may be called about three miles in length, following the general curve of the river, the main channel is down Kentucky side of Sand Island. At low water the channel is very close to island, and around the edge of a ledge of rocks, which extends out abreast middle of island from Kentucky shore. The channel, however, at high water fills up with sand as high as the main shore (on island,) throwing the channel at that time over the ledge of the rocks tolerably close to Kentucky shore; one or the other of these channels is good, but not both at the same time.

Portland Bar, six hundred and two and one-half miles from Pittsburg.—Changeable channel; crosses from Portland to New Albany. At this crossing there are two channels, never both good at the same time; then keeps the Indiana shore to lower end of New Albany, there crosses to Kentucky shore to avoid a high, rocky bar at the mouth of Falling Run, then crosses back to Indiana shore.

The Portland crossing noticed above is a difficult shoal place; boats often stick there. On account of the shifting sands it is doubtful whether wing-dams alone would avail to keep a regular channel. In my first general report it was mentioned at this point that thereafter a more detailed consideration would be given to this place, embracing the Louisville Falls, &c. General Weitzel, now in charge of the falls improvement, has rendered this unnecessary from me. In an able report to a joint committee of Congress, inquiring into the expediency of enlarging the canal, &c., General Weitzel gives some excellent views of the importance of their completion to the vast business of the great West.

In order to save three feet of rock excavation in the canal he proposes a crib-dam at the head of the falls leaving the channel open, but closing the numerous outlets; the dam to back up three feet, for the purpose of deepening the water in the canal.

As the new canal emerges below the falls upon the same rocky stratum underlying the falls and the Kentucky shore, and immediately above the difficult Portland bar, he has properly embraced that in the falls obstruction. He in addition suggests a crib-dam at the lower end of the city of New Albany, to back up four feet at extreme low water, with a sluice at the Indiana side, 1,200 feet long, connecting that pool with the natural pool below, or, if necessary, a lock and dam.

It is important that this place should be improved, otherwise the proposed improvement in general elsewhere would be comparatively useless.

Portland Bar presents the worst feature of the lower river shoals, being subject to change in the shape of the sand-bar with every flood. Even with the proposed crib-dam it is not unlikely that further means will have to be employed to keep the channel permanently unobstructed by sand.

New Albany, Indiana, six hundred and two miles from Pittsburg.—Channel good depth; continues on left, down Kentucky shore, around bend to head of Hughes's Bar, six miles.

Hughes's Bar, six hundred and nine miles from Pittsburg.—Channel here

crosses between two gravel bars to Indiana shore. Seldom any trouble, never in the channel; channel keeps down the right shore to the point where it crosses to Kentucky shore, to Moman's brick house, at 617 miles, called Christopher's Crossing. From Christopher's Crossing the channel is down the Kentucky shore to Dean's wood-yard. Thence the channel crosses to Indiana side, then down that shore to near Strong's Landing, at 621 miles, then crosses to Kentucky shore, thence good water down the shore to mouth of Salt River.

Salt River Bar, six hundred and twenty-four miles from Pittsburg.—Big bar on right below Salt River. Channel close in to mouth of river; crooked, at dead low water difficult to make, but always plenty of water. Channel not troublesome to wood-yard, (at 626 $\frac{1}{4}$ miles.) One mile above New Boston, between wood-yard and New Boston, the channel is close to Indiana shore, quite shoal at extreme low water.

Good water from below New Boston to head of Moman's Bottom, eight miles.

Moman's Bottom Bar, six hundred and thirty-four miles from Pittsburg.—A large sand-bar commences on right, at this place, throwing channel to the Kentucky shore, or left side; thence keeps down that shore to within a half mile of, and above, Tobacco Landing, (at 636 miles,) then crosses over to the Indiana shore. Never any trouble in channel.

Deep water to head of Brandenburg Bar, three and one-half miles.

Brandenburg Bar, six hundred and thirty-nine miles from Pittsburg.—Channel is between two gravel bars, going into this shoal, keeping down the Indiana shore to near the foot of the bar, then crosses to the Kentucky shore just below Brandenburg town, Kentucky. The foot of the bar is sometimes more or less difficult, on account of the changeable channel in shifting sand, though a channel through it can almost always be found.

Good water to Haunted House, Indiana, six miles; although at Mockport (642 miles) there is a long shoal stretch, but no trouble.

Haunted House Bar, six hundred and forty-four and one-half miles from Pittsburg.—The channel crosses to Indiana shore at the mouth of river at Haunted House, and keeps down that shore to near Lop's Landing, (646 miles,) then crosses to Kentucky shore. The Haunted House Crossing becomes quite shoal at extreme low water, shifting a little, but with careful pilotage boats can always run.

Good water thence to head of Upper Blue River Island, nine and one-half miles.

Head of Upper Blue River Island, six hundred and fifty-four miles from Pittsburg.—Channel runs pretty close into Kentucky, or left shore, around the head bar, and along that shore to a little below foot of island, then crosses out into middle of river. No trouble in channel.

Head of Lower Blue River Island, six hundred and fifty-six miles from Pittsburg.—Channel following down middle of river to head bar, then falls in tolerably near to Indiana shore, then quarters out to foot of island to avoid bar at mouth of Big Blue River, then follows under the bar to Indiana shore. No trouble in channel. In extreme low water the channel sometimes cuts through the bar from the lower point of the island to Kentucky shore.

Good water to Schooner's Point, eight miles.

Leavenworth, Indiana, six hundred and sixty-four and one-half miles from Pittsburg.

Schooner's Point, six hundred and sixty-four miles from Pittsburg.—Channel crosses from Indiana to Kentucky shore, between two bars; occasionally the channel is good directly past the point.

Good water to Peckenpaw Bar, five miles.

Peckenpaw Point Bar, six hundred and sixty-nine miles from Pittsburg.—Here the channel crosses from Kentucky to Indiana side, around a large bar in middle of river, shoal at the head. Sometimes gets very shoal, but no trouble.

Good water to Little Blue River Bar, four miles.

Little Blue River Bar, six hundred and seventy-three miles from Pittsburg.—Channel comes in close to Indiana shore, around large bar in middle of river. Much the same as Peckenpaw. Good water in channel. No trouble.

Good water to Flint Island, ten miles.

Flint Island, six hundred and eighty-three miles from Pittsburg—Channel down right side of island, near the middle, to foot; then crosses in close to Kentucky shore to left of a large gravel bar, then keeps down Kentucky shore to foot of bar. Another channel runs down the right of this bar, turning at its foot in to Kentucky shore. From here it comes to middle of river. This is the first serious obstruction thus far below Portland Bar. There seems no doubt that the Indiana channel can be made good at all times by closing the other chute with the dam, as marked in red on the chart. It need not be built higher than to turn the water at a four-foot stage. The stone should be laid on brush foundation to prevent settling into the sand and loose gravel. It will require 9,000 cubic yards of stone. As at other points on the Lower Ohio, occasional dredging in the channel may have to be resorted to, though here it is not probable that it will amount to much, as it is believed that the current will usually clear the sand away itself as the river falls. Good water to head of Oil Creek Bar, one mile.

Oil Creek Bar, six hundred and eighty-five miles from Pittsburg.—Two channels: one crosses into left hand point to left of Middle Bar; the other at extreme low water takes to the right of this bar, close in to Indiana shore, following that shore to near mouth of Oil Creek, leaving shore there to avoid a ledge of rocks below the mouth. This place often gets very shoal. The place is so intimately connected with Flint Island, that it is presumed that improvement here by means of the dam marked on the chart, closing the present low water channel, will be also of some advantage to the latter place. This is a point like French Islands, [referred to in the preliminary remarks on the characteristics of the Lower Ohio,] where sand fills upon the bottom across the entire river. Our soundings, of course, cannot be made to represent the various depths and positions of this bar, as it varies with every flood. Ordinarily the best water is found in the channel across the point, though at very low water it is usual to find deeper water in the bend.

I would call attention to a curious fact here, which I have on the authority of Captain G. W. Rowley, United States consulting pilot, and others, which has elsewhere been noticed as a peculiarity in the action of the Lower Ohio River. The rocks in the bend below the mouth of Oil Creek have frequently been observed to be dry at a very low stage, yet, at other seasons of very low water, when no more water was passing per minute in the river, the same rocks have been *under* water and the channel passing directly over them. This is another instance which conclusively proves how the sand, settling in the river, has the effect of raising low-water surface several feet above what it is at other times at like low-water stages.

The plan proposed for improvement here is, to close the present low-water channel with a riprap dam, as shown on the chart. This leaves the foot of the high-shore bar on the right, and will be about 3,000 feet long, requiring about 8,000 cubic yards of stone.

Both this dam and the one above at Flint Island should be placed on brush to prevent the stones from straying and settling too much in the sand. These two dams will make a shorter and greatly improved channel-course. Some scraping or light dredging will have to be resorted to occasionally to keep the channel clear, as it is impossible to confine the channel permanently by means of dams alone, at such periods when the dams, being covered with sand, cease to further control the current. The amount of this kind of dredging, at any one time, cannot be safely calculated.

Derby, six hundred and eighty-six and one-half miles from Pittsburg.—A village on Indiana side, at head of Shenaut's Reach. At the mouth of a run (Kentucky side) two miles below Derby, the channel is close in to Kentucky shore, then gradually approaches middle of the river, continuing down the middle of the reach to Yellow Bank Creek two miles, then crosses close in to Indiana shore at the mouth of a run, (land-mark here, a house on top of bluff.) From the foot of Shenaut's Reach, at said run, there is a long crossing into bend on Kentucky shore.

Good water thence to Stevensport, three miles.

Stevensport, six hundred and ninety-five miles from Pittsburg.—Stevensport (Kentucky) channel gradually makes off from Kentucky shore around a rough rock bar at the mouth of Sinking Creek, then falling into same shore again. Rome, Indiana side.

Good water to head of Holt's Bar, three miles.

Holt's Bar, six hundred and ninety-eight miles from Pittsburg.—Channel runs obliquely across from left to right shore into the head of the bar and close down the Indiana shore to the foot. At the head it gets quite shoal in extreme low water, but never gives much trouble. There was formerly a cut-off channel at this bar, now closed up. Below this bar the river turns hard to the left. The channel is nearest to Indiana shore to Adam's Run, then crosses to Kentucky shore, close in to the bend.

Good water to Cloverport, six miles.

Cloverport, seven hundred and five miles from Pittsburg.—At Cloverport, Kentucky, and Clover River the channel gradually leaves the shore around Rock Bar at the mouth of Clover River, then back to Kentucky shore at Breckinridge Oil Works; thence down Kentucky shore to Hog's Point good water, five miles.

Hog's Point Bar, seven hundred and ten miles from Pittsburg.—The channel from Hog's Point Bar makes a long crossing into Indiana shore, around a large bar on the left, and keeps down that shore to foot of the bar. The head of this bar never gets shoal, but at the foot the channel sometimes goes out close under the bar, and at other times close in to shore, but never both good at one time; and becomes quite shoal, but not troublesome.

Good water, leaving the shore to avoid Rock Island, three miles.

Rock Island, seven hundred and thirteen miles from Pittsburg.—A mass of rocks, covered in high water. Channel leaves Indiana shore again at lower stone quarry, across to Kentucky shore, into a deep bend around a very large bar in the middle of the river. Channel, when it can be run down the right of this bar is much the nearest, but it is not available at low water.

Good water to head of Troy Reach, three miles.

Troy Reach Head, seven hundred and sixteen miles from Pittsburg.—Here channel crosses close in to Indiana shore, at an old coal chute; keeps that shore to near the head of Tell City, about two miles, then quarters over into the middle of the river, and down the middle, leaving low gravel

bar on the left; when at the foot of this bar, it turns in to Kentucky shore at Kentucky Point, above Troy; from this point it gradually wears out to the middle of the river.

Good water to head of Anderson's bar, fourteen miles.

Anderson's Bar, seven hundred and twenty-eight miles from Pittsburg.—Channel about one-third from Indiana shore to abreast the head of the dry bar, then close in to Indiana shore at upper coal chute, at seven hundred and twenty-nine miles, then keeps down that shore about a mile, then gradually crossing to Lewisport, Kentucky.

Good water to Lewisport, three miles.

Lewisport, Kentucky, seven hundred and thirty-one miles from Pittsburg.—Good water hence to head of Rockport Bar, eight miles.

Rockport Bar, seven hundred and thirty-nine miles from Pittsburg.—The channel crosses at Grand View to Indiana shore, where it gets shoal sometimes below Grand View; but not bad enough to interrupt navigation. From Honey Creek Coal Works, head of Rockport Bar, it crosses over toward bluff at Rockport, closest to Kentucky shore, across the bar. No trouble here. In 1858 Rockport Bar was the shoalest place between Louisville and Cairo.

Good water to Puppy Creek, five miles.

Puppy Creek, seven hundred and forty-four miles from Pittsburg.—Channel crosses from Kentucky to Indiana shore between two gravel bars. No particular trouble, although at extreme low water it gets shoal, but can always be passed when other places are passable.

Good water to Upper Yellow Bank Island, one mile.

Upper Yellow Bank Island, seven hundred and forty-five miles from Pittsburg.—Here channel leaves Indiana shore, crossing out between two gravel bars to middle of river. Near the foot of the upper island it turns to the right, towards the head of the lower island, passing near the head bar of the lower island to avoid ledges of rocks on the left, making out from the Kentucky shore, then falls into the bend near a warehouse, Kentucky side, below the above mentioned rocks.

Good water down the Kentucky shore to Owensburg, at seven hundred and forty-nine miles. Here the channel leaves the bend a little, then back very close in to shore near old pork-house, Kentucky side; and along that bend to near cotton factory at Bon Harbor, seven hundred and fifty-one miles, crossing out into middle of river to avoid rocks on the left.

Good water to head of Little Hurricane Island.

Little Hurricane Island, seven hundred and fifty-two and one-half miles from Pittsburg.—Here the channel runs near Indiana shore to foot of island. Bottom of river is a slate rock the whole length of the island. Gravel and sand bar on the left. Always good water here.

Good water to head of French Island, six miles.

French Island Bar, seven hundred and fifty-eight miles from Pittsburg.—Here channel crosses in close to Kentucky shore, keeping down near that shore to head of dry bar on the right, leaving the shore and following around nearest to the dry bar to the foot of the small island, then turns gradually back to Kentucky shore. The dams built here, it is supposed, by Captain H. M. Shreve, many years ago, have but little influence in controlling the current and channel; they were not probably very high dams as originally built, and since they have settled so much in the sand that their position is sometimes a matter of doubt, until the sand washes away from them. The channel frequently takes over the lower dam, even at low water, leaving the proper course for it choked up with sand. The position of the dams seems very good, but besides

building them higher there may be necessary some regular system of scraping to start the water aright, and aid it in washing out the channel after the freshets have deposited the sand. Fully 15,000 cubic yards of stone and brush will be required here.

Good water from French Island down Indiana side to opposite foot of Willow Bar, Kentucky side. Here channel crosses into Kentucky side below foot of Willow Bar, at seven hundred and sixty-five miles.

Scuffletown Bar and Dam, seven hundred and sixty-seven miles from Pittsburg.—Channel keeps nearest Kentucky shore, to near head of riprap dam at Scuffletown Bar; here it crosses nearly square over along the old dam built by Captain Shreve to coal chute at head of the bluff, Indiana side. The general features of this place are similar to those at French Island, $6\frac{1}{2}$ miles above. There will be about 15,000 cubic yards of stone and brush required at this point.

This place and French Island give more trouble than any points between New Albany and Evansville.

Good water nearest Indiana shore to head of Three Mile Island, three miles.

Three Mile Island, seven hundred and seventy miles from Pittsburg.—Channel runs very close to island, abreast its middle, to avoid a large sand and gravel bar on the left, to near foot of island. Half a mile below foot a dam was built (by Captain Shreve) from Kentucky shore, extending out to middle of river. For a number of years the channel ran through a gap in this dam, but at present the channel runs down to and around the foot of the dam, as it was originally designed. After passing the dam it rounds to under a large bar on the right, and thence to Indiana shore. For several years this place has not given so much trouble, but the dam should be repaired. It will require 12,000 cubic yards.

Good water to Green River Tow-Head, two miles; Green River at 775 miles.

Green River Tow-Head, seven hundred and seventy-seven miles from Pittsburg.—One mile below head of Green River Island, on the left side of the island. There is a flat ledge of slate rock in bottom of river between tow-head and Kentucky shore. Channel along Kentucky shore over this place is narrow, but has plenty of water. (An old dam was built on the upper side of Green River. I suppose it was in connection with the Green River navigation.)

Good water down Kentucky shore in the bend to Evansville, Indiana, six miles.

Evansville, Indiana, seven hundred and eighty-three miles from Pittsburg.—The channel follows edge of gravel bar on the left to full abreast of the landing, then crosses to Indiana shore above mouth of Pigeon Creek, Indiana, at lower end of the city. The bar on the Kentucky point, a little below Evansville, is the highest on the river, extending out at low water past the middle of the stream.

Good water to foot of Tobacco Bend, five miles.

Dutch Bend, seven hundred and eighty-eight miles from Pittsburg.—A very heavy bend. The crossing into head of Dutch Bend gets shoal sometimes, but never obstructs navigation. High gravel and sand bar on the Kentucky side opposite Dutch Bend. Water in channel good at foot of Dutch bend. Here channel leaves Indiana shore to near Kentucky shore, keeping down nearest to Kentucky shore to left of Henderson Tow-Head.

Henderson Tow-Head, seven hundred and ninety-three miles from Pitts-

burg.—Above Henderson, Indiana, channel has good water down to head of Henderson Island, three miles.

Henderson Island, seven hundred and ninety-six miles from Pittsburg.—Here channel crosses in to near Indiana shore. A pile dam was built many years ago from Indiana shore. Channel runs near to Indiana till above the dam, then crosses over and turns down between bar at foot of island and a very large bar on the right, which throws it close to Kentucky shore; it then follows the bend, leaving a large bar on the right all around the point. Water occasionally quite shoal in places, but never gives much trouble except in extreme low water.

Foot of Cypress Bend, eight hundred and six miles from Pittsburg.—The foregoing description answers as far as this bend. Deep water here to head of Diamond Island, two miles.

Diamond Island, eight hundred and eight miles from Pittsburg.—Channel on Indiana side very close to main shore at head, to avoid the large head-bar continuing down near that shore to foot of the big island; at foot of main island crosses over to near middle of the tow-head, then crosses the reef and down about middle of river. Water enough in the channel.

Walnut Bend, eight hundred and fourteen miles from Pittsburg.—At head of this bend the channel turns close in to the Kentucky shore, leaving a very high gravel and sand bar on the right; thence down the Kentucky shore to foot of bend, in good water; from here it crosses square over to Indiana shore.

Good water down Indiana shore to head of Lafayette Bar and tow-head, $4\frac{1}{2}$ miles.

Lafayette Bar and tow-head, eight hundred and eighteen and a half miles from Pittsburg.—Channel above tow-head crosses to Kentucky Point opposite to Mount Vernon, leaving the bar and tow-head on the right; from this point it crosses out into middle of the river. Ledges of rock make out from Indiana shore all the way to Slim Island, (two miles,) but there is plenty of water and room to avoid them.

Mount Vernon, Indiana, eight hundred and nineteen miles from Pittsburg.—Deep water behind the tow-head to Mount Vernon. Straight Island is now closed up with the main land, Kentucky side. It may be worth examining, to ascertain whether a channel could be formed to run behind the tow-head past the town.

Slim Island Head, eight hundred and twenty-two and a half miles from Pittsburg.—Channel crosses very close in to Indiana shore below a ledge of rocks, keeping that shore to foot of island, leaving a high gravel and sand bar on the left; then crosses from Indiana shore close to mainland a little above the foot, where it turns to the right, leaving three small tow-heads on the left. Below these tow-heads it gets shoal, and causes trouble sometimes. Wide river below.

Good water thence to head of Mississippi Bend.

Mississippi Bend, eight hundred and twenty-eight miles from Pittsburg.—A long, sweeping bend to the right. At the head of this bend channel crosses close to Kentucky shore, continuing in the bend down to Poker Point, (830 $\frac{1}{2}$ miles,) leaving high gravel and sand bar on the right. Channel keeps pretty close around this point, to avoid Upper Highland or Touisana Rocks on the right.

Good water to Highland Rocks, (lower,) about two miles.

Lower Highland Rocks, eight hundred and thirty-four miles from Pittsburg.—The channel here is narrow between the rocks on the left; high sand-bar on the right. At the foot of this bar the channel crosses to

Kentucky shore below the rock. The extreme foot of this bar changes sometimes, making it difficult on that account.

Good water to mouth of Wabash River, about four miles, passing Wabash Island.

Head of Wabash Island, eight hundred and thirty-six miles from Pittsburg.—The largest island on the Ohio River. (A fine ice-harbor on Kentucky side, half a mile above this island.) Regular channel is on the Indiana side of this island. Island is $4\frac{1}{2}$ miles long, and $1\frac{1}{2}$ mile wide.

Mouth of Wabash River, eight hundred and thirty-eight and a quarter miles from Pittsburg.—This river is the boundary between Indiana and Illinois. After passing mouth of Wabash the channel runs close to Illinois shore, and keeps it to near foot of Wabash Island, then crosses to Kentucky shore below the foot of the island. The foot of the island is two miles below the mouth of the Wabash River, at $840\frac{1}{2}$ miles.

Good water in channel to head of Shawneetown Bar.

Brown's Islands, eight hundred and forty-four miles from Pittsburg.—A chain of islands, beginning about two miles below foot of Wabash Island, and extending to head of Shawneetown Bar, along Illinois shore. Regular channel, with good water, to left of this chain.

Shawneetown Bar, eight hundred and forty-six miles from Pittsburg.—This is one of the worst places on the Lower Ohio River, and causes a great deal of trouble. Sandy shoal and changeable channel. Before 1867 the channel was always down the right of the bar, but since that date it has been down the left, as shown on the chart. A dam from the Illinois shore would confine the water to its present channel. Such a dam would be not less than 3,500 feet long, requiring about 13,000 cubic yards of stone.

Shawneetown and below, eight hundred and forty-eight miles from Pittsburg.—There is a high ledge of rocks from the Illinois side, making out into the middle of the river just below the town landing, but good water around it. After passing the rocks the channel runs gradually in to the Illinois shore to the head of Shawneetown Bend, leaving a large bar and tow-head on the left, thence down the Illinois shore to below the foot of the above bar and tow-head.

Shawneetown Bend, eight hundred and fifty miles from Pittsburg.—Shawneetown Bend, continuing from last. The channel crosses out to the middle of the river, and then back again gradually in to the bend; thence down the Illinois shore to the foot of the bend. Here commences what is called Cincinnati Bar.

Cincinnati Bar and Tow-Head, eight hundred and fifty-two miles from Pittsburg.—The channel at the head of the bar crosses over close to the Kentucky shore between two large sand-bars, and keeps that shore to near Curlew coal-works, opposite the mouth of Saline River. There it leaves the Kentucky shore, quartering into the middle of the river. Will need improvement eventually.

Good water thence to Sellers's Landing.

Sellers's Landing and Shotwell's Coal Works, eight hundred and fifty-nine miles from Pittsburg.—Here the channel crosses close in to the Kentucky shore, above Shotwell's coal works, and keeps down the Kentucky shore to near the mouth of the Slue. Here it crosses between two sand-bars to Battery Rock, Illinois. Abreast of Shotwell's coal works there is a middle bar. The channel sometimes takes down the right side of it, so, instead of turning in, it takes right down, passing between the said bar and tow-head and a bar on the right.

Battery Rock, eight hundred and sixty miles from Pittsburg.—The chan-

nel below Battery Rock keeps nearest to the Illinois shore to near the head of Treadwater Island, though gradually leaving it, crossing back again nearest to the Illinois shore, a little above Treadwater Island.

Treadwater River, eight hundred and sixty-two miles from Pittsburg.

Treadwater Island, eight hundred and sixty-two miles from Pittsburg.—Channel keeps nearest Illinois shore along here to the head of Treadwater Bar. No particular trouble.

Treadwater Bar, eight hundred and sixty-three miles from Pittsburg.—Several years ago this place gave more trouble than any other on the Lower Ohio. It gets as shoal here as at Shawneetown. If one is improved the other should be also. The channel shifts, being sandy. After passing the bars, it keeps down the Kentucky shore to the head of Cave-in Rock Island.

Weston, Kentucky, "Flynn's Ferry," eight hundred and sixty-four miles.

Cave-in Rock Island, eight hundred and sixty-seven miles from Pittsburg.—Just below the head the channel runs from the Kentucky shore over to the Illinois side and keeps along below rocky bluffs to the head of Walker's Bar, 4 miles. No trouble in channel.

Walker's Bar, eight hundred and seventy miles from Pittsburg.—Here the channel crosses square over to the Kentucky shore, leaving a very large bar (Walker's) on the right, thence down the Kentucky shore to the bend of Big Hurricane Island, leaving a large bar on the right; thence crosses toward the head of the island and continues down left of the island. Walker's Bar has been very troublesome of late years.

Big Hurricane Island, head, eight hundred and seventy-three and one-half miles from Pittsburg.—The channel is down the Kentucky side of the island. About the head of this island and above it the channel becomes very shallow and crooked, which, with the number of wrecks, makes the navigation at low water exceedingly difficult. The channel at one time ran between the upper tow-head on the right, and the head of the upper main island, when it was much straighter than at present. It now shows symptoms of cutting through here again, and probably if it does take through, the channel will be more easily navigated. The wrecks about the head of the island should be taken out at all events. This channel continues down the Kentucky side, generally nearest to the island to near its foot, when it passes to middle of river. At the foot it crosses to near the Illinois shore.

Foot of Big Hurricane Island, eight hundred and seventy-seven miles from Pittsburg.—Channel continues below island along the Illinois side, with plenty of water to the head of Irish Jimmy's Bar, about $3\frac{1}{2}$ miles.

Elizabethtown, Illinois, eight hundred and seventy-seven miles.

Rosa Clara Landing, eight hundred and seventy-nine and a half miles.

Irish Jimmy's Bar, eight hundred and eighty and a half miles from Pittsburg.—Here, just below the bluff, a high bar on the Illinois side throws the channel over to the Kentucky side, a little below Buck Creek, then keeping that shore to foot of bar; thence plenty of water to head of Grand Pier Bar, 4 miles.

Grand Pier Creek Bar, eight hundred and eighty-four and a half miles from Pittsburg.—Very large bar; makes out from the Kentucky side, and throws channel over to the Illinois shore into an elbow, then turns short to the left, and down the Illinois shore to foot of Golconda Island, 5 miles.

Head of Golconda Island, eight hundred and eighty-eight and a half miles from Pittsburg.—Channel on the right side of island. The Kentucky side gets dry at a five-foot stage. Not often run, except in very high water.

Foot of Golconda Island, eight hundred and ninety and a half miles from Pittsburg.—Channel here leaves the Illinois shore, crossing out below the foot of the island, near left-hand dry bar, then keeps near the middle of river to head of First Sister Island, four miles.

Golconda, a town on the Illinois side, eight hundred and ninety miles.

Head of First Sister or Prior Island, eight hundred and ninety-two and a half miles from Pittsburg.—Channel rather closest to the island, on Illinois side. First Sister Island about $1\frac{1}{2}$ mile long. A number of loose rocks along the right of this channel could be removed with benefit to navigation. The channel at the foot of this island sometimes gets shoal, and is changeable, making it occasionally difficult. Good water then near the Illinois shore to head of the Second Sister Island, 2 miles.

Head of Second Sister Island, eight hundred and ninety-six miles from Pittsburg.—(A Third Sister Island laps on the right-hand one. In a low stage there is no water between the two lower Sisters.) The channel leaves the Illinois shore, and comes out close to head of Second Sister Island, around a large gravel and sand bar on the right, then keeps down the bend, leaving a large gravel and sand bar on the left, and rock bar on right, at mouth of Bay Creek.

Mouth of Bay Creek, Illinois, eight hundred and ninety-eight miles from Pittsburg.—A bay-like looking place on the river here. Good water from Bay Creek, Illinois, to head of Steuart's Island, three miles.

Steuart's Island, head, nine hundred and one miles from Pittsburg.—Here channel runs close to Kentucky shore, down to foot of the timber on the main land, then gradually wears to middle of river.

Good water to head of a tow-head on left, two miles.

Tow Head, nine hundred and three miles from Pittsburg.—Below this tow-head the channel runs close to Kentucky shore, keeping it to the foot of the bar; then crosses out towards Dog Island, past the middle of river, and down, rather nearest island to near its foot, where it crosses to Kentucky shore again, leaving a large sand-bar on the left.

Foot of Dog Island, nine hundred and seven miles from Pittsburg.—The channel then keeps to Kentucky shore to left of small tow-head. This tow-head is rapidly disappearing. It is probable that in a few months it will be gone. A riprap dam was built many years ago across from foot of Dog Island to head of Cumberland Island, but it did not stand well; considerable money has been expended in trying to keep it up. It now appears to have a good solid foundation. To keep the channel down the left of Cumberland Island, and past the mouth of the Cumberland River, it is very important that this dam should be rebuilt. It may require as much as 18,000 cubic yards of stone and brush.

Head of Cumberland Island, nine hundred and seven and a quarter miles from Pittsburg.

Cumberland River, nine hundred and eight and a quarter miles from Pittsburg.

Foot of Cumberland Island, nine hundred and nine and three-quarters miles from Pittsburg.—Good water in the channel past the mouth of the Cumberland River to foot of island. From foot of island over to "Pull-tight" is occasionally troublesome, but from "Pull-tight" across to below old Smithland is an extremely shoal place that gives a great deal of trouble. There is always water enough to make good navigation if it were confined in one channel. After leaving Old Smithland there is no trouble in the channel to the crossing of Cottonwood Bar, two miles. These channels from the head of Dog Island to the foot of Cumberland Island occasion great trouble to boatmen, and it is important that they should be improved. As to the manner of improving

this place much will depend upon the effect of the proposed dam at the head of Cumberland Island.

Crossing of Cottonwood Bar, nine hundred and twelve and a half miles from Pittsburg.—The channel crosses from Kentucky to Illinois shore, and down along Illinois shore to Alida Point.

Alida Point, nine hundred and fifteen miles from Pittsburg.—Here the channel crosses to Kentucky shore, leaving a large gravel and sand bar on the left, called "Indiana Bar."

Good water down Kentucky shore to head of Tennessee Island, about three miles.

Head of Tennessee Island, nine hundred and eighteen and a half miles from Pittsburg.

Tennessee River, nine hundred and nineteen and three-quarters miles from Pittsburg.

Paducah, Kentucky, nine hundred and twenty miles from Pittsburg.—Below mouth of Tennessee River. (Very fine view on the Ohio River from Paducah down for about 10 miles—very wide.) The channel from Paducah keeps down the opposite, or Illinois side, to the foot of the large bar and tow-head. (The water in channel from Paducah to Metropolis, Illinois, about 10 miles, is generally shoal, but never causing any trouble.) From the foot of the tow-head above mentioned the channel is near the middle of the river to about a mile below Brooklyn.

Brooklyn, Illinois, nine hundred and twenty-three miles from Pittsburg.—At one mile below this town the channel makes a long crossing, falling in to Illinois shore at Belgrade, ($3\frac{1}{2}$ miles,) leaving a large gravel and sand bar, called "Fort Massac Bar," on the left.

Belgrade Landing, nine hundred and twenty-six and a half miles from Pittsburg.—Channel runs near Illinois shore, and continues so to Metropolis, Illinois. Above Metropolis half a mile is "Fort Massac."

Metropolis, Illinois, nine hundred and twenty-nine miles from Pittsburg.—Metropolis is a very flourishing place, where many boats are built. It has a fine site for a navy yard. Good water from Metropolis to head of Little Chain, one mile; channel makes a long crossing over to Kentucky shore.

Little Chain, nine hundred and thirty-one miles from Pittsburg.—Here the channel crosses from the Kentucky to the Illinois shore, between two large gravel and sand bars. After crossing in here there are rough ugly rocks on both sides of the channel, but plenty of water and room in the channel.

Good water down Illinois shore to Fletcher's Landing, three and a half miles.

Fletcher's Landing, nine hundred and thirty-seven miles from Pittsburg.—The last good tow-boat landing above Grand Chain. From Fletcher's Landing the channel crosses over toward the Kentucky shore past the middle of the river, thence down nearest the Kentucky side.

Wilkinson's, head of Grand Chain, nine hundred and forty-two and one-half miles from Pittsburg.—The channel here crosses toward the Illinois shore to within a quarter of a mile of the Illinois side, to avoid a large gravel and sand bar on the left, and follows this bar around to within a quarter of a mile of the Kentucky shore, keeping about that distance from shore to foot of chain. Wilkinson's is a place on the chain where steamboats can land on the Illinois side, among the rocks, if the pilot is familiar with their position. The channel below Wilkinson's gets extremely shoal, sometimes filling up so much with sand as to compel boats to run near shore among the rocks.

Jackson's Rock, nine hundred and forty-three and one-half miles from

Pittsburg, in the Grand Chain near the channel, ought to be removed. It is a rough ledge or point, only visible at extreme low water.

Cedar Tree, nine hundred and forty-eight and one-half miles from Pittsburg.—The channel runs across from near the Kentucky side over to the Illinois side, to a ravine just below the old "Cedar Tree," an old mark for pilots, and at this point ends the trouble of the "Grand Chain." The tree has recently fallen down. There is no doubt that a great many wrecks of various kinds of vessels now lying in and near the channels of the Grand Chain ought to be taken out. A system of lights for night-running is very much desired by pilots; it will require three lights.

Caledonia, Illinois, nine hundred and fifty-one miles from Pittsburg.—Good water and fine landing; good water from the foot of Grand Chain to Cache Island, seven and a half miles.

Cache Island, nine hundred and fifty-six and one-half miles from Pittsburg.—Channel above the head of the island is nearest the Illinois shore, and keeps down that shore to near the head of the tow-head on the right, then leaves the shore, passing out between main island and tow-head. When near foot of tow-head crosses in to the Illinois shore at Mound City, at lower end of Cache Island. Cache Island channels give no trouble, except when the Mississippi is extremely low.

Mound City, Illinois, nine hundred and fifty-nine miles from Pittsburg.—Channel runs between a flat ledge of rocks on the left, and tow-head and gravel bar on the right, thence down the Illinois shore to Cairo, leaving a large gravel and sand bar on the Kentucky side, extending to within about two miles of Cairo, thence deep water to Cairo.

Cairo, nine hundred and sixty-seven miles from Pittsburg.—At the mouth of the Ohio River, in the forks of the Ohio and Mississippi Rivers. The site of this now flourishing city is in great part artificial, the ground being naturally low and overflowed in freshets. The water is kept out by artificial mounds or high levees; the floods sometimes rise forty feet above low water; it is of course subject to the floods of both the Ohio and the Mississippi. Cairo is chiefly important as the southern terminus of the Illinois Central Railroad.

Recapitulation of plans.

LOCKS AND DAMS.

The principal advantage of the plan of locks and dams for the Ohio River consists in the fact that, in the very driest seasons, at its extreme lowest stage, there is water enough to maintain a permanent navigation—always not less than 6 feet, or even a greater depth if deemed advisable; but since the material change which has taken place in the mode of navigating this stream, by the introduction of the barge system, with powerful towing steamers, taking fleets of ten, twelve, sixteen, or more of the large coal boats and barges each trip, the question has become much more complicated.

Many years ago the writer prognosticated the change that afterward took place in the general mode of navigating the Ohio, and, in 1857, urged, as one of the reasons for the radical improvement of the river, "that the old fashion of conducting the coal business between the Upper and Lower Ohio and the Mississippi Valley will, from choice and from economical motives, be entirely abandoned. Barges will be substituted for the *frail arks*, which now not only never return, but in too many instances never reach their destination. Consequent upon this change, the coal business will rapidly and largely increase beyond the calcula-

tions of the most sanguine." This change has taken place already to a great extent, even without the improvement of the natural navigation; and the change is so extensive and radical in its nature as to introduce a new element in the consideration of different plans for the improvement of the navigation, which cannot be overlooked in the present discussion.

In consequence of this new and very important feature it would now seem to be a necessity, in considering the improvement problem in connection with the particular plan of locks and dams, to make provision for navigable chutes in the dams of sufficient capacity to pass the largest coal fleets with safety—chutes not less than 300 feet wide.

With chutes of this size, flattened at each side so that the navigation through them would be safe with a very moderate freshet in the stream, the question respecting the needful dimensions of the locks is also affected. Without the addition of capacious navigable chutes (for ascending navigation) in the dams, the natural impression would be that the lock, or, if double, one of the locks, at each dam, should be of the very largest size, costing, consequently, a large sum in the first instance, and large sums annually for their maintenance and management; but if such navigable, large chutes are provided, it is scarcely to be doubted that a vast amount of the annual business, especially of the coal trade, would be conveyed through the chutes or over the dams, without using the locks, excepting in low water, a period covering usually from two to four months of the season. With such an arrangement it is possible that locks of less dimensions than the extremely large size hitherto proposed might answer. The largest size, to correspond with the new locks of the enlarged canal at Louisville, would be 80 by 370 feet in the chamber. A lock 60 by 300 feet is large, and it will pass steamers of very heavy tonnage, if a good depth of water is provided. Probably, upon a critical investigation, it may be deemed advisable to adopt a depth of 7 feet for the low-water depth, in case locks and dams should be adopted, which depth would be, of course, increased as the river should rise.

The Erie Canal Company of Pennsylvania, who own the canal from Beaver, 26 miles below Pittsburgh, to Erie, on the lake, a distance of 136 miles, propose to enlarge its dimensions so as to give 7 feet depth of water all the way from the Ohio to the lake, making a continuous water communication with not less than 7 feet navigation from the Ohio River to the Hudson River, *via* the Pennsylvania Erie Canal, the lake, the enlarged New York Erie Canal, and the Hudson River to New York; so that when the Ohio shall be permanently improved, so as to be constantly 6 or 7 feet deep, merchandise, coal, iron, &c., can be shipped from Pittsburgh, Wheeling, Marietta, Parkersburg, Cincinnati, Louisville, New Albany, Evansville, Cairo, Memphis, New Orleans, St. Louis, Quincy, Keokuk, Burlington, Davenport, Dubuque, St. Paul, and all other ports on western waters to Lake Erie and the upper lakes, and eastward as just indicated. From an intimate knowledge of the Pennsylvania Erie Canal, (having been its chief engineer from 1839 to 1845,) I am enabled to state that the cost of enlarging it so as to attain 7 feet depth of water and a wide canal, with locks 20 feet wide and 120 feet long, sufficient to pass vessels of 300 tons burden, will not probably exceed three millions of dollars. Upon the completion of this enlargement, with the corresponding improvement of the Ohio, the general river trade of the West will be largely benefited, and the business, especially the coal, iron, and ore traffic, vastly augmented.

Many years ago the State of Pennsylvania contemplated the construc-

tion of a canal along the Ohio River between Pittsburg and Beaver, with a view to a continuous canal navigation from Pittsburg to the lake at Erie and Cleveland; but before work had been commenced the policy of the State was changed, and her public improvements, one after another, were allowed to pass into the hands of private or individual corporations. About the same time the United States Government was engaged in the partial improvement of the Ohio River by means of rip-rap wing-dams, &c., but after 1844, the whole matter rested, until the summer of 1866, when the General Government resumed charge of the Ohio River, and recommended its improvement.

There are several months every year when vessels drawing 6 feet of water can navigate between Pittsburg and Beaver without further improvement of the river; but of course it is very desirable to secure such a navigation during the residue of the season whenever the river should be unobstructed by ice.

It has already been suggested, that the dams, in case of the adoption of slack-water navigation on the Ohio, should be planned low, not to exceed six feet from pool to pool. It may be advisable, in order to afford great facility for the passage of coal fleets, (without compelling them in moderate freshets to go through the locks,) to construct two dams, about four or five hundred feet apart for each lift, dividing the fall so as to make it but 3 feet at each dam; or as a substitute a very long chute, dividing the 6-foot lift through four or five hundred feet opposite the lock.

The estimated cost of a system of locks and dams between Pittsburg and Louisville, 598 miles, with provision for long chutes and moveable regulating gate, is \$17,052,207.

RESERVOIR PLAN.

Of the reservoir plan of Mr. Ellet it may be said: *First.* As a means of regulating the floods of the Ohio River so as to confine them to an equable flow or any practical approach thereto, it is impracticable. *Secondly.* As a means of affording in low-water seasons a constant flow of five to six feet depth in the natural river-channels, while the plan is not really impracticable, it will necessarily be accompanied by very serious difficulties in its practical accomplishment, besides great cost in construction, and a heavy annual expense for its management. I have presented certain data which afford an approximate or rough estimate of the probable cost, although accuracy cannot be obtained without an extensive system of special surveys. But the probable or possible error of estimate would not be sufficient to affect essentially a fair consideration of the plan as compared with other plans.

The cost of managing, operating, repairing, and maintaining an extensive system of reservoirs, must of course depend upon circumstances. A few large reservoirs or gigantic river-pools constructed on the main streams, (if admissible now,) would be cheaper to manage and operate than a large number of scattered isolated reservoirs on the tributaries located over an area of many thousand square miles of territory, though the idea that such very high dams, having elevations of from 60 to 100 feet, can be made available for two distinct and different purposes, namely, for reservoir use and for slack-water navigation, is certainly fallacious. Practically, as soon as a few feet in depth of water should be drawn from the surface of the pool, the slack-water navigation would for the time being be destroyed. It would be suspended until the pool should again be filled or nearly filled. The

combination or union of the two things is impossible, without some very peculiar and novel arrangement, which may be regarded as unattainable for every-day use. Therefore, in considering the Alleghany River or the Monongahela River, thus radically changed by means of these very high dams into a gigantic reservoir system or systems, we must also consider that navigation upon them would be practically destroyed upon those parts of the streams. These very high dams on the greater portions of the main streams are therefore deemed inadmissible; and this fact, if recognized, fixes the general character of reservoirs. Should they be adopted for the purpose proposed, they would, of necessity, be located on the tributaries where they have much more fall per mile than the main streams, and where consequently a dam of given height would pond back much less water. Hence it is safe to assume, not as a mere theory, but as a reliable result of the actual unavoidable attendant circumstances of the problem, that a large number of reservoirs will be necessary, and that their first cost would not be likely to be less than \$60,000,000. It has been shown that at present prices of work 300 reservoirs of similar capacity with the Conemaugh reservoir would be likely to cost \$300,000 each, or \$90,000,000 in all, and that 30 reservoirs of a much more advantageous character would be likely to cost not less than \$1,000,000 each, or \$30,000,000 in all. An average between these estimates would be \$60,000,000. I think, therefore, that \$60,000,000 is not an extravagant sum to assume for the probable first cost of an adequate reservoir system.

Allowing three of the larger class to be practicable at \$1,000,000 each, or \$3,000,000, it would leave 270 of the smaller size at \$3,000,000 each, or \$81,000,000, which, adding the \$3,000,000, would make \$83,000,000. Under the present circumstances, with the present lights before us, I should not consider myself justifiable in encouraging an opinion that any less sum than sixty millions of dollars could accomplish the result desired, even supposing that the sites for all these reservoirs were really at hand, and practically attainable, and that their construction would be fairly admissible. My opinion is that the various interests to be affected by such a very extensive system of reservoirs, which would be chiefly in Western Pennsylvania, are of such an important and complicated nature as to render the whole plan nearly or quite impracticable on that account. This, of course, could only be finally determined after thorough surveys; but suppose the system to be completed as indicated, with 273 reservoirs scattered along the western base of the Alleghany Mountains, between Western Virginia and New York State. To manage the system would involve a telegraphic arrangement between Pittsburg, as the initial point for the supply at the head of the Ohio, and each of these reservoirs, with at least one man at each to answer the signals and attend to the reservoir pipes and valves, in order to regulate the flow of water. If the works were properly constructed in the first instance, they ought not to cost much for ordinary annual repairs, but it is only reasonable to allow for the contingency of an occasional accident among so many reservoirs. The breaking of a large reservoir might be productive of considerable damage, for which the Government would, in justice, be responsible. The drawing down of some of the reservoirs in summer might not be unhealthy; the drawing down of others might create sickness. It is not deemed necessary to enter upon detailed estimates of the probable cost of managing, operating, and keeping this system in repair, when so much depends on the particular circumstances, which could only be ascertained by the most careful and elaborate surveys; but I would not venture to offer an estimate of the

probable cost at less than two thousand dollars annually for each reservoir, or, for 273 reservoirs, \$546,000 per annum for such assumed number of reservoirs, without any allowance for extraordinary contingencies or accidents.

With these facts and general views before us, the Department can form a tolerably fair judgment respecting the merits of the reservoir system.

Plan of dams, mounds and canal.

MR. HAUPT'S PLAN.

This plan, projected by Mr. Haupt, has been described. An estimate of its probable approximate cost is contained in Mr. Livermore's paper discussing the plan proposed by himself.

In the absence of a careful survey of the river designed with special reference to this particular plan, it is obvious that an accurate estimate of cost is unattainable. Yet there are fixed features which afford some data upon which to estimate the probable cost of the principal items with a tolerable degree of certainty. The dams across the river may be regarded as similar, for any given height, in all the plans which involve dams.

The number and height of the dams being established, the general character of their accompanying mounds becomes known to a certain extent; thus admitting of what may be termed a minimum estimate of cost, enabling us to determine that it could not be less than such an amount.

Owing to the greater declivity of the upper portion of the river, extending from Pittsburg down about thirty miles, the fall being at the rate of about $1\frac{1}{4}$ foot per mile, the proposed mound would be unbroken, forming, in fact, a continuous canal, with the descent of $1\frac{1}{4}$ foot per mile. Below that point, assuming the average descent of the canal to be placed at 1 foot per mile, it would require the mounds to occupy about half the distance along the river; the dams to overcome in the aggregate the total fall on that part of the river. This would leave about half of the entire length of the river (below the thirty-mile point just mentioned) in the shape of clear, unobstructed pools, and about half in the shape of a side-canal navigation of such width as might be fixed upon. Mr. Haupt, in his original paper, referred to a width of 200 feet. With fifty per cent. more water-supply this could, of course, be made 300 feet wide. But this increase of water-supply, for the low-water period, would necessarily require a large additional expenditure in the construction, repair, and management of artificial reservoirs for storing the water.

Allowing each dam to raise the water 7 feet, with a depth of six feet in ordinary low-water for navigation, the dams would be not less than 13 feet above the bed of the stream; and allowing 2 feet additional for irregularities of the bottom, the average height of the dams would be 15 feet.

Fifteen feet at the least would therefore be the height of the surface of the pool in the canal, above the average bed of the stream at the dam. And allowing one foot per mile declivity in the flowing canal, the mound would extend, say three and a half miles above, and three and a half miles below the dam, being an average of seven miles in length of mound at each dam; or, if preferred, each dam might be located at the extreme upper end of the mound, the mound in that case extending seven miles below. Then the mound would be not less than fifteen feet

high at the upper end, gradually tapering down to not less than six feet at the extreme lower end. It would, however, probably be found cheaper and better to locate the dam some distance below the upper end of the mound, and perhaps at or near the middle of its length might prove to be the most advantageous.

With the dam placed half way of the length of the mound, the canal surface, in low water, opposite the dam, would be, according to the theory, three and a half feet below the level of the upper pool, in three and a half miles having overcome the upper half of the total fall of the dam. Hence, at first view it might appear that below the dam the mound could at once be reduced three and a half feet in height, and thus save considerable embankment in the mound. The proper height of the mound would of course have to be determined practically by the circumstances at each location. It would not answer in any case to have it only just as high as the surface of the canal in low water; it should be high enough to maintain the canal navigation intact till the river in times of freshets should flow several feet deep over the dams; but experience shows that with one-foot rise on the upper pool near the dam, a rise of from two and a half to three feet, according to circumstances, occurs just below the dam; therefore the mound could not with safety be reduced in height immediately below the dam. With a rise of three feet at the dam, on the upper pool, an average rise of from seven to nine feet might be assumed at the head of the adjoining pool below. Taking it at eight feet, the difference of level would thus be reduced from the original low-water difference of seven feet to two feet. And with a rise of five or at most six feet on the dam, the fall would be changed very nearly to the regular slope of the stream, when vessels could safely pass over the dams in both directions, and need no longer confine themselves to the side canals.

With chutes in the dams, descending craft of moderate draught could pass them safely with even three feet depth on the dams; but there is an objection to chutes in dams forming part of this proposed system of mounds and canals, (unless arranged with movable gates,) on account of the greater quantity of water that would have to be procured artificially by means of costly reservoirs, owing to the additional flow through the chute.

The plan in its main features is therefore to be considered as originally presented, (without chutes.)

Approximate estimate of cost of dam and mound.

From Pittsburg dam, 30 miles, at \$73,700 per mile..... \$2,211,000

Average cost of dam and 7 miles of mounds, &c.:

Dam and abutments complete	\$98,920
Mound, 475,000 cubic yards, at 40 cents.....	190,000
Slope wall, 119,000 cubic yards, at \$1 75.....	208,250
Puddle ditch, 35,000 cubic yards, at 60 cents.....	21,000
Excavation and cross embankment, 334,000 cubic yards, at 35 cents.....	116,900
	<u>635,070</u>

\$635,070 multiplied by 36, equal..... 22,862,520

25,073,520

Add 10 per cent. for contingencies and engineering..... 2,507,352

Total approximate estimate on 967 miles..... 27,580,872

Allowing that reservoir provision might be required for ninety days, for the difference between the low-water flow (100,000 cubic feet) and the quantity required in a canal six feet deep, 1.25 per mile descent, 377,000 cubic feet per minute, difference 277,000 cubic feet per minute; or, for ninety days, 35,899,200,000 cubic feet, or something over one-fourth of the quantity required on Ellet's plan; requiring about \$15,000,000, making a total in round numbers of \$42,000,000.

The cost of a radical improvement of the navigation of this river ought to be regarded as a minor consideration, in view of such an improvement. The difference of a few millions of dollars between the best plan and an inferior plan should not lead to the choice of such inferior plan.

The real question is, which is the best plan? General Haupt's plan has some advantages as well as disadvantages not possessed by other plans.

Advantages.

1. It would accomplish a very desirable result in affording an ascending and descending navigation without the obstruction of locks.

2. It would cost less for superintendence and annual repairs along the river than the plan of locks and dams, or than the plan proposed by Mr. Livermore, though the cost for superintendence and repairs of the artificial reservoirs would have to be added. The amount of this would depend on the width and depth assumed for the artificial navigation. If arranged for three hundred feet width, this item would be very important.

3. It would be less liable to injury from ice, &c., than the plan of locks and dams, or than Mr. Livermore's plan, provided the mounds were properly constructed in the first instance, and protected from injurious abrasion by slope walls or good riprap walls on the slopes and top, as indicated by General Haupt.

4. There would be none of the delays caused by locks, though there would be some retardation to ascending boats from the current passing through the canal, and some aid from the same current to descending boats.

Disadvantages.

1. On account of requiring the aid of artificial reservoirs, on a large scale, the difficulty of securing advantageous locations for immense reservoirs is considerable, and their first cost would be a heavy item. The cost for repair and management, however, might be materially less than that of the locks. Unquestionably, however, the cost of erection, and the constant future expense attending the repair and management of artificial reservoirs, is an objection very similar in its nature to the objection against locks. Yet it is to be recollected that no thorough improvement of this river can be effected on any plan that is free from objections analogous to this.

2. The plan renders a continuous river canal necessary all the way from Pittsburg to below the mouth of Big Beaver, or say thirty miles. And this canal would, of course, be only on one side of the river, accommodating the people only on that side, and leaving those on the other side without navigation in low water; practically cutting them off from access to navigation, excepting when the river should be in flood, so that steamboats and other craft could pass over the dams.

3. Below this continuous canal, where one-half the length would be clear pools, and the other half canal on one side of the river, a different

state of navigation would be created in low water. At those parts of the stream where there should be pools free from the canal mounds, both sides of the river would be accommodated, while, opposite the canal portions, the people across the river would be practically cut off from the navigation, excepting, as before mentioned, in times of floods. Places near to the dams, and on the opposite side from the canal, would be the most difficult of access; steamers or other craft, in order to touch at such points during low water, or moderate stages, would be obliged to run the length of the mound, (half the length twice,) or say seven miles extra, to accomplish it. It is true that the canal need not necessarily be built all the way on the same side of the river. Probably it might be cheaper and better to build it on some parts of the river on the other side; but this would be merely shifting the difficulty above described across the river, without, in the slightest degree, remedying it. One side would still be partially cut off from the free use of the improved navigation.

4. Ferries, opposite any of the canal stretches, would cover the whole length from Pittsburg to below Big Beaver, thirty miles, and half the length from there to Louisville would be most seriously interfered with, if not rendered useless during low-water periods. There would then be two streams to cross instead of one, the artificial mound requiring a transfer of freight and passengers over the mound, from one ferry-boat to another ferry-boat. The private and public skiff crossing could not be made in low or moderate stages of the water without rounding the cape of the mound in the pool of the dam, thus forcing those living near the dams to row about seven miles extra, to make one crossing of the river; unless they carried the skiff over the mounds.

5. The confined width of the canal, even if enlarged, as suggested, to 300 feet, with a current of two to three miles an hour, would prevent large steamers from rounding to for landings on their descending trips. As there would not be room for that purpose, they would be compelled to touch head on, descending as well as ascending.

6. Wherever the canals should be made there would be required more or less excavation along the shore to secure the requisite depth of water; and at the mouths of creeks and runs, entering on that side, during heavy freshets, there would be more or less fresh deposit of gravel, &c., in the canal. It would be much more subject to such deposits with the mound standing as an obstacle to the free flow of the creeks and runs across the river than the river is now without such obstacle. So that frequent dredging might become necessary at some of these places, perhaps at many of them. In fact, the formation of troublesome or dangerous bars in the comparatively narrow canal receiving these heavy flood discharges would seem to be almost inevitable. At present, when such bars form, the steamers, &c. have room to sheer off from them on a wide river, though they are objectionable even then.

7. The effect of these mounds, occupying half the length of the main river, standing 200 or 300 feet, as the case might be, from one shore, might be to change essentially the general regimen of the river, not only in the canal part, but outside of the mound in the main stream. The natural regimen of every important river like the Ohio is attained by the continued operation of two chief causes, namely, the direct flow of the main stream, and the lateral flow of the side tributaries into the main river; the effect of these being in some cases materially modified by the intervention of islands, bends in the river, and the direction in which the tributaries enter. The introduction of a new element in the shape of continuous mounds, several miles in length, built near one shore, might change the character of the natural navigation materially.

8. Although the river, improved on this principle, might be much better in low or moderate stages than the present inferior low-water navigation, these mounds would, in certain higher stages, become serious impediments, and even dangerous obstacles, particularly in connection with the tow-boat system. Thus, when there would be a natural flow of eight to twelve feet, which is a good coal-boat stage, these mounds would be for the most part covered with water, but not to a sufficient depth to permit the deeply laden coal barges and steamers to pass over them. The natural river at such times would therefore be practically narrowed for this trade to the extent of the 200 or 300 feet, besides the width of the mound. The case, in its practical operation, would, however, be far worse than the mere contracting of the natural width. There would be serious additional risk of striking the invisible mounds, even in daylight, and in the night the risk would be much greater. This is not referred to as an insuperable objection to the adoption of the plan, but as one of the unavoidable disadvantages attendant upon the use of the river after such mounds should be erected.

Recapitulation and views of Mr. Livermore's plan of patent chutes.

This plan has been elaborately described by Mr. Livermore, and is accompanied by a drawing. It is as he describes it, a substitute for locks, the dams still being necessary, as in the case of locks and dams. It, in fact, consists of a dam with a novel arrangement of a long flat chute, on a principle which causes retardation in the flow of the current by the reaction of the water created by bottom obstructions, placed below the regular bottom plane of the chute and open side chambers, and further reaction created by the cross walls extending at frequent intervals on both sides of the inclined channel or chute. According to Mr. Livermore's calculations and experiments, made by him on a small scale, the theory and the practical operation correspond closely, leading him to the conclusion that a chute arranged on this plan may be so constructed as to save about two-thirds of the water that would naturally flow through a plain, unobstructed chute of similar declivity. The inclination which seems to be preferred by Mr. Livermore for chutes for the Ohio River of about 100 feet width, is 4 inches for 100 feet, making for 7-foot lift of dam, 2,100 feet total length of chute. By inserting twice as many cross-walls, according to his theory, half the quantity of water would suffice, the velocity being reduced in that proportion.

There can be no question that a chute arranged on the plan proposed will reduce the velocity of the flow and thus afford a greater depth with the same quantity of water, or the same depth with a smaller quantity of water. There may be streams where this principle can be advantageously applied; but there are special reasons existing in connection with the navigation of the Ohio River which render it difficult of application, if not impracticable for that stream.

It presents an advantage in time in the passage of the chute as compared with passing through the lock for single steamers and other craft occupying less than the width of the chute; but it is not adapted to the passage of fleets of coal boats or fleets of barges, either floating or in charge of towing steamers; in this particular respect being, like the lock, too narrow for that mode of navigating the Ohio. And as the system of barges in fleets with towing steamers is gradually superseding the old method of freighting by single steamers, or single pairs of coal boats, or single boats, &c., this fact should be kept in mind and allowed its proper weight in the consideration of plans for the radical

improvement of the navigation. It is true, however, that at present the coal business is entirely suspended in low water. During low water these chutes could be navigated by single steamers and having fleets reduced in size, arranged differently from the high-water fleets, with tows not more than two or three boats in width. Even then, a practical difficulty would be encountered in navigating the river at stages which, in its present natural condition, are good for coal-boating and general freighting. With dams and this peculiar arrangement of chute, the navigation would not be safe for large fleets of boats until there should be a sufficient rise in the river to enable them to pass over the dams and over the walls of the chutes. Whereas, if the chutes were specially designed only for freshet navigation, and made not less than 300 feet wide, this objection would not exist.

The walls of these chutes, whether of stone, or wooden cribs filled with stone, owing to their peculiar arrangement and position, and great length along the stream, would be liable to injury from ice and floating logs, roots, &c., in times of freshets; much more so than the walls of a properly located lock. The dams might escape injury from a flood that would injure the walls of a chute of this character, while the spaces between the walls would be especially liable to catch and retain drift-wood, roots, wrecks, &c.

On these accounts, while this plan possesses merit, and may be worthy of a practical test on a large scale, it is not of such a character as to warrant an engineer in recommending it for adoption as a system on the Ohio River. The inventor, Mr. Livermore, would not himself recommend the immediate adoption of this plan as the permanent system for this river. All that he expects is that it shall be fairly tested, on a scale of sufficient magnitude to determine its merits in a practical manner. There are other objections which might be referred to in connection with this particular plan as a system for the Ohio River; but no plan is free from objections. I have endeavored to present this particular plan fairly, but without any intention of urging it for adoption in preference to other plans, for the radical improvement of this important river. Nor would it be proper for me prematurely to condemn it as wholly inapplicable, although I believe that it will not prove to be the best, or the proper plan for creating a permanent navigation of the Ohio.

CONCLUDING REMARKS.

It might at first view seem to be an easy task, with the information and experience which have been obtained, to present confidently some definite plan for the permanent, radical improvement of the entire river; yet with all the light before us that I have been able to attain, the problem is still so much involved by a variety of conflicting considerations as to render its solution somewhat complicated. Any single plan for the entire river, that can be proposed, will encounter objection from some quarter; but it is not from any apprehension or fear of encountering objection that I have hesitated to make decisive recommendations. My reluctance springs from the fact that many of the effects likely to accrue, or which may accrue from the adoption and completion of any radical improvement of this river navigation, can scarcely be foreseen, or at least cannot now be clearly and fully comprehended, but will remain to be eliminated only by actual experience in the working of whatever plan may be finally selected.

The adoption of a wrong plan, or even of an inferior one, if a more perfect plan is practicable, might subject the country to serious loss in-

stead of conferring a national benefit, and those who may be instrumental by their labors and arguments in establishing any plan involving large expenditures in its execution, will justly be held accountable at the bar of public opinion.

So far, however, as my investigations have enabled me to form a judgment respecting the different proposed methods, I can have no hesitation in expressing opinions, the merits of which will of course be judged of by the Department when studied in connection with all the information of every kind in your possession relating to the Ohio River.

The preceding report presents for consideration five different modes of permanently improving the Ohio River, besides views respecting the improvement of the low-water navigation :

1. Locks and dams with chutes, along the Ohio, making a regular slack-water navigation on nine hundred and sixty-seven miles of river.

2. Reservoir plan, consisting of numerous small reservoirs on the upper branches or heads of the tributaries of the Alleghany and Monongahela Rivers, or of a few large reservoirs on the main tributaries farther from their sources ; the object being to store up the surplus rainfall, and to draw off the reservoirs to fill the Ohio River to a navigable depth during the dry or low-water season ; no work to be done on the main river.

3. Low dams in connection with longitudinal river mounds, or embankments, dispensing with locks ; arranged to equalize the flow through the side channels, (formed by these river mounds,) not less than two hundred feet in width, requiring reservoir supplies, but a much less additional quantity of water than would be necessary without contracting the river channels, as proposed.

4. Livermore's plan of dams and patent chutes, substitute for locks.

5. A regular steamboat canal along one side of the river, and also a notice of Bonnot's hydraulic gate.

Approximate estimates accompany the exposition of these several plans, from which it appears that their estimated cost is—

1. Locks and dams with chutes.....	\$23,777,662
2. Reservoirs, (Ellet's full plan).....	60,000,000
3. Low dams and mounds, with auxiliary reservoirs.....	42,000,000
4. Dams and patent chutes for 100 feet width of channel.....	17,437,133
5. Canal, continuous.....	54,000,000

From which it appears that on the plans considered, the lowest approximate estimate of cost is \$17,437,133, and the highest is \$60,000,000.

It will be understood that these estimates are nothing more than approximations.

In considering the plans for the permanent improvement of this river, I regard the cost as a secondary matter, in comparison with the vital importance of obtaining the best method practicable—such a plan as will in the long run hereafter prove to be the best attainable for the public good, and which will best accommodate the vast river interests dependent upon this navigation. A few millions more or less either way do not make a question of much public importance, in the determination of the primary question just mentioned.

A presentation of the facts and arguments bearing upon these several plans for the improvement of this particular river, would be but a repetition of the text of my general report ; for justice cannot be done to them in a brief synopsis, on account of the variety of circumstances and views which have to be taken into account.

I am not prepared to recommend the adoption and prosecution, on the whole river, of either of these plans. For the Upper Ohio, the quantity of water required to be stored up in artificial reservoirs is so great, and would be attended with so many practical difficulties, that I deem the all-reservoir plan inadmissible.

Mr. Livermore's method of substituting chutes for locks and for retarding the current, thus saving water, although scientifically developed, would be attended with practical difficulties, which render it in my view impracticable on the Ohio, however well it might be adapted to other streams not possessing the same peculiarities. The plan of low dams, with a comparatively narrow canal on one side of the river, has merit, though it involves artificial reservoirs; but the obstacles in the way of rendering such a plan constantly reliable and useful, and so as to give general satisfaction along the river, seem to me to be insurmountable. The plan of a steamboat canal along one side of the river has no special advocates; but, independently of that, I could not recommend it for adoption. It would not be that which is so much desired, the improvement of the navigation of the Ohio River.

For the Upper Ohio, from Pittsburg down to some as yet undetermined point on the river, considered by itself, slack-water navigation would appear to be the most desirable, but, for the reasons which are given in my study of the plan of locks and dams, I think that none but low dams with chutes should ever be placed there, or in any part of the Ohio River. On the other hand, for the Lower Ohio, from Louisville to Cairo, I would not at present advise the introduction of a pure slack-water system, but rather an improvement of the natural channels by means of low open dams, and dredging in part, at certain points, by confining and guiding the flow of the river.

Meanwhile, in case a system of locks and low dams should be entered upon, beginning at the head of the Ohio, the low-water improvements could be continued on the intermediate distance thence to Louisville. Notwithstanding all the experience and the excellent success of slack-water navigation on other rivers, I do not think it would be safe or desirable to involve the Government by adopting irrevocably, and by the appropriation of large sums toward the immediate consummation, along the whole river, of any one plan that has ever been proposed. This foregoing suggestion is advanced under the impression that whatever may be done or attempted in the way of a radical improvement of this stream, designed to meet the public expectation, will partake to some extent of experiment; I mean by this, that if we had now a perfect, finished slack-water navigation on the Ohio from Pittsburg to Cairo, it would require time and many changes in business arrangements all along the river to render its use satisfactory to river men and the public generally; but by beginning the system at the head, and extending it down stream only as far and as fast as its extension should be demanded, the business on the river would gradually and quietly conform to the changed condition of things.

Although I have adverted to navigable chutes through the low dams, and included them in the estimated cost of locks and dams, their construction and use must be considered in some degree experimental for the trade of this river. It may prove to be the case in practice on this river that these chutes can be so arranged and managed as to afford an ascending and descending navigation (independently of the locks) for a larger portion of each season than has been assumed; and experience hereafter may demonstrate that with the aid of the flow from a few reservoirs, managed in connection with these chutes, a good navigation

may be secured along the Middle and Lower Ohio, without locks. With the river confined by means of water-tight dams of moderate height, and forced to flow through one channel limited at the dam to about three hundred feet, the quantity of water required to maintain a six-foot navigation in ordinary low stages and five feet in extreme low stages along those parts of the river where the fall is not over four or five inches per mile, will be very much less than the vast quantities required to maintain similar depths along the natural unimproved river, as in the case of the reservoir plan.

The circumstances of the Ohio River are such that it is impracticable to apply a rigid mathematical theory in advance which will fully meet the practical results of any artificial system of improvements, on account of the material difference in the declivity of different portions of the natural river, and the great number of tributaries entering at various points increasing the volume of water, though at irregular intervals both in distance and times; the least volume being where the greatest declivity occurs, 15 inches per mile, near the head, and the greatest volume where the least declivity is found, $2\frac{1}{2}$ inches per mile, for a hundred miles above the mouth.

It is obvious that even the same quantity of water might, if judiciously controlled, give good navigation on the lower end of the stream, which, on the upper end, having six times the declivity, would practically afford none at all; but since the quantity is always very much greater, the contrast becomes more striking, and furnishes a sufficient argument in itself against a premature adoption of a lock and dam system on the Lower Ohio, even should it be constructed on the Upper Ohio.

As the quantity of water in the river increases as we descend, while at the same time the declivity is materially diminished, this feature is favorable to the indicated system of dams confining the water to a given width, and which would make such a navigation better and better in approaching the lower end; but as the river in its natural condition becomes gradually very much wider in descending, the flow from reservoirs if built above the head of the Ohio, which might materially increase the depth near the head in the narrow, low-water channels, by the time the unevaporated portion should reach the lower end of the river, would have little effect on the natural navigation of the wide river. It is proper to remark here, however, that the general theory may be correct, that if the upper part of the Ohio, say from Pittsburg to Wheeling, were kept supplied with water enough to maintain six feet depth in the natural channels, the navigation would be good enough below.

In one point of view the construction and use of locks and dams on the Upper Ohio may not be regarded as entirely experimental; for the Ohio from Pittsburg to Wheeling very much resembles the Monongahela between Pittsburg and Brownsville in its general characteristics, though very much more abundantly supplied with water, having the Alleghany River in addition to the flow from the Monongahela. The experimental points are two: the manner in which the chutes can be worked, and the effect of transferring the making up of the large coal-boat tows to a point below the head of the Ohio.

The circumstances, however, along the Monongahela and those along the Upper Ohio in their natural condition, before the completion of the slack-water on the Monongahela, were not the same; for owing to the comparatively small quantity of water, excepting in floods, on the Monongahela, the natural navigation was of little account, whereas the artificial navigation created by the dams and locks has been of immense

benefit to the whole valley, to the city of Pittsburg, and to every place along the Ohio and Mississippi where coal is consumed.

The natural navigation on the Upper Ohio, although the declivity is greater than on the Monongahela, is far superior to that formerly on the Monongahela, rendered so by the greater flow from the Alleghany. The present may be a favorable period for commencing the construction of locks and dams on the Upper Ohio, (if that plan is ever to be adopted on any part of the river,) in connection with the proposed enlarged canal from the Ohio River at Beaver to Lake Erie, a distance of 136 miles.

The fall from Pittsburg to foot of Beaver Shoals is $31\frac{1}{2}$ feet, (or 14 inches per mile,) in a distance of 27 miles. Assuming that the first dam should be located at the foot of Bonnot's Island, 3 miles, where the pool is 4 feet lower than the pool at Pittsburg, there would be $27\frac{1}{2}$ feet fall in 23 miles, which could be divided into 5 lifts of $5\frac{1}{2}$ feet each, making six dams in all, including the outlet dam and lock for the Ohio River, on the assumption that for the time being the slack-water should extend no farther down the Ohio. The estimated cost of this navigation is, in round numbers, \$2,000,000 for the 27 miles.

If the people generally, and the citizens of Pittsburg and the Upper Ohio, should favor this plan, here would seem to be the place to test fully this method of improving the Ohio. The use of these six dams would settle the question practically, and if found to work well there, the system could be extended down the river to such point as experience might determine to be advisable.

Although, for the purpose of comparison with other plans, an estimate of the probable cost of a slack-water navigation from Pittsburg to Cairo has been submitted, amounting to \$23,777,662, yet, since the circumstances are such that there is no reasonable probability of adopting locks and dams below the falls, (or, perhaps, even as far down on the Upper Ohio as the falls,) it is not proper to retain that estimate as applicable to a modified system consisting partly of locks and dams with chutes, and below that partly of improved channels without locks. With abundance of water at command (properly controlled) on the Lower Ohio, and on the lower portion of the Upper Ohio above Louisville as high as Cincinnati, and even higher, the plan of confining and guiding the water through long sluice-ways will very greatly improve the navigation without locks and without the addition of supplies from artificial reservoirs, and at less aggregate cost.

Even should a system of locks and dams for the Upper Ohio and of improved channels for the Lower Ohio be adopted, there might be, if hereafter deemed necessary, a still further improvement of the navigation below the locks and dams by means of a few reservoirs, the practical beneficial effects of which would be very much greater along the artificial channels than if allowed to spread over the entire natural bed of the river.

In such event the reservoirs could be placed on any of the rivers or tributaries above the lower lock, wherever that might be.

Summary of views respecting the plan for the permanent improvement of the river.

As the general result of the investigations of the natural regimen of the Ohio River, in its various very different stages of high, intermediate, and low water, and the differing characteristics of the Upper and Lower Ohio, especially in moderate and low stages, taken in connec-

tion with the nature of the business heretofore done and now doing on the river, and looking to its probable future extent, it would seem that the question of the proper mode of permanently improving the entire navigation is more complicated than has been generally supposed.

Any plan, (for example, that of locks and dams with navigable chutes,) which might serve a good purpose on the Ohio, above Cincinnati, more especially on the extreme upper portion, might not prove to be advantageous on the Lower Ohio, or even on the lower portion of the Upper Ohio.

There can be no doubt of the ample supply of water for a system of locks and dams along the entire river; but the necessity for the introduction of such a system is not nearly so great on the Lower as it might be deemed on the Upper Ohio, owing to the fact that the natural navigation is not so often, or so long, or so seriously interfered with below as it is above; and to another fact, which has an important bearing, namely, that the floods on the Lower Ohio are more frequent, higher, and of longer duration than they are above. This is owing to two principal permanent causes—the greater number of considerable tributary rivers, draining large areas of different regions of country, and the lessened declivity in the stream, thereby reducing comparatively the rate of the flow. Thus, while the Upper Ohio, from Pittsburg to below Beaver Falls, (twenty-eight miles,) descends at the rate of very nearly fifteen inches per mile, the Lower Ohio, from Louisville to Cairo, (a distance of 336 miles,) descends at an average rate of only about three inches per mile. And while the average width of the Upper Ohio, from Pittsburg to Parkersburg, (a distance of 183 miles,) is about 1,500 feet, the average width of the Lower Ohio, from Louisville to Cairo, is over 2,000 feet.

The minimum flow of the Upper Ohio, between Pittsburg and Parkersburg, in very low water, may be put at about 100,000 cubic feet per minute, (although in extreme low stages it is sometimes even less,) while the minimum flow of the Lower Ohio is rarely less than 200,000 cubic feet per minute.

In one important respect dams on the Lower Ohio would be more advantageous, or less obstructive to the natural river, than on the Upper Ohio. In consequence of the reduced fall per mile, each dam would pond back a materially greater distance, making the pools very much longer, and thus, on a given distance, reducing the number of dams and locks. A dam seven feet high above Beaver would make a pool less than six miles long, whereas a dam seven feet high between Louisville and Cairo would make a pool about 28 miles long. The lockage on a slack-water navigation is, of course, in proportion to the fall of the stream; the less lockage on a given length, the better, more valuable, and cheaper the navigation. At the same time we are to consider this always in juxtaposition with the peculiar character of the several portions of the Ohio River, not overlooking the important circumstance the natural low-water navigation of the Upper Ohio, and that there is a much larger volume of water available, in connection with other proposed plans for the improvement of low water navigation, on the Lower Ohio.

Excepting on rare occasions, it may be assumed that at present there is a natural navigation of three feet depth during low-water periods all along the Ohio River below Louisville, or at least, with a comparatively moderate expenditure, such depth may be maintained, even during the driest seasons; and that for a large portion of the year there is a depth of four feet or more in the channels. Under these circumstances,

although it might be proved that a system of locks and dams, by which six or seven feet depth could be secured at all times, would create a better navigation than is now afforded in low water, it is to be considered that for upward of half the year the natural navigation, being six or more feet in depth, is better than the artificial slack-water. So that if the Lower Ohio is to be studied by itself, independently with any connection with the residue of the Ohio River, there is sufficient reason for pausing before undertaking the introduction of locks. Nor should we lose sight of another important fact, that the Lower Ohio is not only very similar in its characteristics to the Mississippi between the mouth of the Ohio, and below to Memphis, and above to St. Louis, but that it forms with the Mississippi one navigation.

The Mississippi channels, within the range mentioned, and for some distance below Memphis and above St. Louis, sometimes fall nearly as low as in the Lower Ohio, though the low-water periods do not generally correspond in point of time, the lowest water in the Mississippi being usually during the months of July and August, and in the Ohio in September and October.

Although the extreme low-water navigation of this part of the Mississippi may be regarded as having a little more depth than that of the Lower Ohio, the difference would scarcely be deemed sufficient to determine in favor of artificial slack-water, with locks in the one and not in the other, if the whole subject covering both streams were under consideration.

The instructions of the Department do not require from me any special or other examination of, or report upon, the Mississippi River, yet from the fact of their close union with each other, and their intimate relations in commercial and navigation interests, it seemed appropriate to refer to the Mississippi in this connection.

On the other hand, the commercial navigation intercourse between the Upper and Lower Ohio is also at all times very intimate; and where the water is at a medium, or any higher stage, the falls being practically obliterated, it becomes one river, navigable from Pittsburg to Cairo; not only to Cairo, but to New Orleans and to the Upper Mississippi and the Missouri. It is then all one great river navigation, the grandest in the world.

Again, although locks and dams with movable chutes should work well and prove highly advantageous on the Upper Ohio, they might not prove equally advantageous on the Lower Ohio, owing in part to the difference already mentioned in the characteristics of the two portions of the river. The greater frequency of the submergence of the locks, and the greater natural accumulations of mud and sand deposits below Louisville, must also be taken into account. Owing to more frequent and higher floods than on the upper river, the locks would be covered oftener, unless the walls were raised to a greater height, making them much more costly in construction, and more cumbersome in working. It is obvious from what has been stated, that in general there would be but a short period each season when the locks would be used, especially if there were open chutes in the dams.

The larger supply of water on the Lower, as compared with the Upper Ohio, and the vast accumulations of sand, forming extensive and shifting shoals, considered in connection with the greater natural depth of channel in low stages, and the more frequent and higher freshets, rather tend to the conclusion that locks, as a part of a system on that part of the river, may not prove satisfactory.

An exposition has already been given in this report of proposed plans

for what has been termed the low-water improvement, or the amelioration of the river in its low stages.

The next proposition in order on the Lower Ohio, excluding locks, may be a regular system of low dams and long, permanent chutes, which, with the quantity of water at command, will probably afford a good navigation of from four to six feet depth during the low stages, of course increasing in depth as the river should rise. Brush and stone dams might answer best if carefully located, so that there should be only about four or five feet fall from one pool to another, with open chutes three hundred feet wide and a mile in length, with the sides of the chutes composed of brush and stone, or in some places a combination of piles, brush, and stone. The objection to the ordinary timber crib-dam built on sand, is the risk of its destruction in consequence of the stones settling into the sand, allowing the timber portion to be partially floated, so that the current, in times of flood, might wash it out of place; while experience has shown that dams of moderate height, constructed of brush and stone and of piles, have resisted the action of the stream for many years.

The system here indicated may be regarded as an extension of the low-water improvement beyond the plan of local wing-dams heretofore employed at certain points on the Lower Ohio, without carrying it to a complete slack-water system with locks. It might be aided in some cases by dredging, though dredging in general in the Lower Ohio would only be a temporary expedient, requiring repetition.

It is not certain that a slack-water navigation, with dams of very moderate height, on the Lower Ohio, would always maintain the full depth of water in the channels, where, from natural, permanently operating causes, they are now subject to the obstructions of periodical sand-bars. The bends of the river, the islands, and the debouching of the side tributaries, may be considered as permanently operating; and the erection of low dams would not probably have a very material effect in modifying their action, excepting, perhaps, near the dams.

It is therefore important that due care should be exercised in the location of the works, as well as in the particular plan; attending in each case to all the circumstances which might affect the final action of the stream after their construction. The floods of the Lower Ohio, rising forty feet or more above the usual low water of the river, are sufficient to overcome the tendency of the sand to settle in the partial pools which the low dams would form during the moderate stages. An ordinary rise of six feet on the Lower Ohio would bring the surface of the river nearly to a regular plane, and, long before attaining the full height of ordinary freshets, it would flow much the same as if the low dams had no existence. In all cases the chutes should be located as nearly as possible in the line of the natural channel of the stream, so that they might be either in the middle or on one side or the other side of the river, according to the circumstances at each dam.

One advantage of this system on the Lower Ohio of low dams and long chutes without locks would be, that in case hereafter it should be deemed expedient to increase the quantity of water in the upper river in its low stages by artificial supply from reservoirs, such increase would be more effective in adding to the navigable depth of the channel than the unobstructed river would be; that is, a given quantity of water added to the natural low water flow would both improve the navigation sooner and maintain it longer; and the same beneficial effect would, of course, take place from all the natural freshets, whether small or great.

Occasionally there might be a season when, owing to general drought

throughout the valley, the waters of the Lower Ohio would be very low, when, without artificial supply, the available channel depth during such drought might be less than three feet. It is partly in view of this anticipated event that a system including locks has its principal merit; but since the dams and chutes may easily be constructed and tested, irrespective of the locks, and the locks, if deemed necessary, could afterward be built on the Lower Ohio, I would not feel warranted at this time in recommending the erection of locks below the falls, even if dams with locks should be deemed most advantageous on the Upper Ohio.

If I have succeeded in conveying clearly to the Department the views which my investigations have induced, they will be prepared to estimate the practical value of the several suggestions contained in the summary. If it should become the fixed policy of the Government to make the large appropriations necessary for the radical improvement of the navigation of the Ohio, the most that I could now recommend, with the light at present before me, would be the construction of a few low dams, chutes, and locks on the upper portion of the stream, beginning at Pittsburg, and extending, say as far down as the foot of the falls below the mouth of Beaver River, embracing about twenty-eight miles, involving an expenditure of about two millions of dollars; meanwhile the low-water improvements, removal of snags, wrecks, and other obstructions, to proceed as already recommended. The stone in the wing-dams of the low-water improvements could nearly all be made available in the filling of the dams erected for the slack-water, along the same portion of the river.

Respectfully submitted.

W. MILNOR ROBERTS,
United States Civil Engineer.

The Appendix, which is a part of this report, contains:

1. Summary of profile of the Ohio River, distances, height above tides, lengths and fall of ripples, &c.
2. Table showing number and length of river pools over seven feet depth at low water.
3. River and rain gauge records.
4. Report upon the commerce of the Ohio River.

SUMMARY OF PROFILE, OHIO RIVER.

Table exhibiting elevation above tide, fall for every mile, and the length and local fall at ripples. (Fractions of distances to places in first column.)

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		Mls.	Feet.	Feet.	Feet.		Miles.	Feet.	Feet.
13 $\frac{1}{2}$	Pittsburg	0	701.640						
24 $\frac{1}{2}$	Saw Mill Run	1	701.558	0.060					
34 $\frac{1}{2}$	Cork's Run	2	700.440	1.140					
4 $\frac{1}{2}$	Chartier's Creek.....	3	697.890	2.550		Rowley's Channel.	3 $\frac{1}{2}$	600	2.25
	Jack's Run	4	697.744	0.146					
		5	697.544	0.200		Horsetail Ripple ..	5 $\frac{1}{2}$	1,280	2.43
		6	695.144	2.430					
		7	694.788	0.326		Lowry's Ripple	7 $\frac{1}{2}$	2,700	2.00
		8	692.648	2.140		Duff's Bar	8	4,130	2.56
		9	690.088	2.560		Merriman's Ripple.	9 $\frac{1}{2}$	2,900	1.86
	Glendale	10	689.688	0.400	11.952				
		11	687.814	1.874		White's	11	1,738	2.64
		12	685.174	2.640		Wollery's Trap	11 $\frac{3}{4}$	2,300	2.41
		13	682.764	2.410					
		14	682.364	0.400		Deadman's Ripple.	14 $\frac{1}{2}$	3,250	4.41
	Flothery's Run	15	677.954	4.410					
	Big Sewickley Creek ..	16	677.554	0.400					
	Little Sewickley C'k ..	17	676.534	1.020		Lit'e Sewickley Bar ..	17	2,000	1.02
		18	676.224	0.310		Logstown Bar.....	18 $\frac{1}{2}$	5,000	2.69
		19	673.534	2.690					
20 $\frac{1}{2}$	Baden, Pa.....	20	673.384	0.150		Crow Island.....	20	2,600	0.52
		21	672.864	0.520	28.776				
		22	672.354	0.510		Waller's Ripple	22 $\frac{3}{4}$	2,600	0.51
		23	672.232	0.122					
25 $\frac{1}{2}$	Big Beaver River ...	24	672.090	0.142		Lacock's Bar.....	24 $\frac{1}{2}$	5,000	0.85
		25	671.570	0.520	30.240				
		26	671.215	0.355					
	Vanport, Pa.....	27	670.170	1.045		Beaver Shoals.....	26 $\frac{3}{4}$	3,950	1.89
		28	669.125	1.045					
		29	668.925	0.200	33.240	Raccoon Shoals.....	28 $\frac{3}{4}$	3,000	0.65
		30	668.280	0.645					
32 $\frac{1}{2}$	Safe Harbor, Pa....	31	668.020	0.260					
		32	667.820	0.200	33.820	Montgomery's Isl'd ..	31 $\frac{3}{4}$	5,600	1.10
		33	666.720	1.100					
34 $\frac{1}{2}$	Shippenport, Pa....	34	666.470	0.250					
		35	665.570	0.900		Phillis Island	35	5,000	1.16
		36	663.370	2.200					
36 $\frac{1}{2}$	Potts's Run, Pa....	37	663.810	0.560	38.830				
		38	662.610	0.200		Georgetown Island.	37 $\frac{1}{2}$	5,280	1.85
		39	660.760	1.850					
	Little Beaver River.	40	660.535	0.225	41.105				
		41	660.315	0.220		Line Island.....	41	1,460	1.20
		42	659.200	1.115					
		43	657.307	1.893		Babb's Island	43	340	0.65
	Liverpool, Ohio.....	44	657.027	0.280	44.613				
		45	656.827	0.200					
		46	656.617	0.180					
		47	656.467	0.180		Wellsville Bar	47	2,500	0.80
	Wellsville, Ohio....	48	655.667	0.800	45.973				
		49	655.557	0.110		Baker's Island	49	5,100	1.58
50 $\frac{1}{2}$	Yellow Creek, Ohio ..	50	653.977	1.580	46.663				
		51	653.727	0.250		Clusters.....	51 $\frac{1}{4}$	6,700	2.30
		52	651.427	2.300					
	Tumbleson's Run, Va.	53	651.171	0.256	50.469	Black's Island.....	53 $\frac{1}{2}$	8,750	2.81
		54	650.155	1.016					
		55	648.899	1.256					
56 $\frac{1}{2}$	New Cumberland, Va.	56	648.343	0.556	53.297				
		57	648.150	0.184					
		58	647.979	0.180					
		59	647.799	0.180					
	King's Creek, Ohio ..	60	647.599	0.200	54.041	Brown's Island.....	60 $\frac{1}{2}$	21,100	3.77
		61	647.224	0.375					
		62	645.594	1.630					
		63	644.764	0.830					
	Cable's Eddy.....	64	643.824	0.940	57.816				
		65	643.624	0.200		Will's Creek and Ferry Bar.	65	5,500	2.86
		66	642.057	1.567					
		67	640.768	1.289					

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		Mls.	Feet.	Feet.	Feet.		Miles.	Feet.	Feet.
67½	Stenbenville, Ohio...	68	640.518	0.250	61.000	Wells Run Bar....	68	2,500	1.10
		69	639.523	1.095	.....	Mingo Island.....	69½	5,400	1.10
		70	639.587	0.136	.....				
		71	638.489	1.098	.....	Cross Creek and	71	7,900	2.80
		72	637.123	1.366	.....	Cox's Bar.			
		73	635.693	1.430	.....				
73¾	Wellsburg, Va.....	74	635.443	0.250	66.197	Buffalo Bar.....	74	3,000	0.80
		75	634.689	0.754	.....				
		76	634.444	0.245	.....				
		77	633.769	0.675	.....	Beach Bottom Bar.	77½	4,000	1.56
		78	632.885	0.884	.....				
		79	632.809	0.076	.....				
		80	632.757	0.052	.....				
	Warrenton, Ohio...	81	631.839	0.918	69.801	Short Creek Bar..	80½	3,000	1.50
		82	631.256	0.583	.....				
		83	631.036	0.220	.....	Pike's Island.....	82¾	5,400	0.88
		84	630.154	0.882	.....	Twin Island.....	84½	7,480	1.40
		85	628.754	1.400	.....				
	Burlington, Ohio...	86	627.904	0.850	73.736	Burlington Bar...	86	4,000	1.76
		87	626.794	1.110	.....				
88½	Martinsville, Ohio..	88	626.691	0.103	74.949				
		89	626.554	0.137	.....	Wheeling Island..	88½	10,560	4.80
	Wheeling Creek, Va	90	624.375	2.179	.....				
	Wheeling, Va.....	91	622.473	1.903	79.167				
		92	622.173	0.300	.....	Bogg's Island.....	92	4,500	1.99
		93	620.185	1.988	.....				
	McMahon's Creek..	94	620.062	0.123	81.578	McMahon's Creek.	94	2,000	1.99
		95	618.074	1.988	.....				
		96	617.516	0.558	.....	Six-mile Ferry Bar	96	10,350	1.14
	Kate's Rock, Va....	97	616.934	0.528	84.706				
		98	616.736	0.198	.....				
		99	616.468	0.268	.....				
		100	614.802	1.666	.....	Little Grave Creek Bar.	99½	3,000	1.87
	Moundsville, Va....	101	614.338	0.464	87.302	Big Grave Creek Bar.	101½	2,000	1.18
		102	613.030	1.308	.....				
		103	612.870	0.160	.....				
		104	612.697	0.173	.....				
		105	612.547	0.150	.....				
		106	612.397	0.150	.....				
		107	612.247	0.150	.....	Captina Island....	106¾	4,500	3.65
108¾	Captina Creek, Ohio	108	612.076	1.171	.....	Captina Creek Bar.	108½	1,000	0.58
		109	609.573	2.503	92.067				
		110	608.996	0.577	.....				
		111	608.589	0.407	.....				
	Fish Creek, Va.....	112	608.261	0.328	.....	Fish Creek Island.	111¾	5,400	2.20
		113	606.336	1.925	95.304				
		114	605.866	0.470	.....	Cline's Bar.....	114	5,000	2.60
		115	603.719	2.147	.....				
		116	603.419	0.300	.....				
	Sunfish Creek, Va..	117	602.969	0.450	98.671	Sunfish Creek Bar.	116¾	2,500	1.33
		118	601.639	1.330	.....				
		119	601.549	0.090	.....	Opossum Cr'k Bar.	118¾	4,000	2.42
		120	599.349	2.200	.....	Roger's Bar.....	120½	2,000	0.91
121¾	Proctor's Run, Ohio.	121	598.441	0.908	103.200	Proctor's Run Bar.	121¾	4,500	1.85
		122	596.591	1.850	.....				
		123	596.484	0.107	.....				
		124	596.372	0.112	.....				
		125	596.190	0.182	.....	Mackeldownies B'r	125¼	2,000	0.80
		126	595.392	0.798	.....				
	Fishing Creek, Va..	127	595.268	0.124	106.372	Fishing Creek Bar.	127	4,000	2.09
		128	593.180	2.087	.....				
		129	593.081	0.100	.....				
130¾	Sardis, Ohio.....	130	592.966	0.115	108.674				
		131	592.866	0.100	.....	Pedan's Island....			0.48
		132	592.386	0.480	.....	Williamson's Isl'd.	132	10,800	2.50
		133	591.144	1.242	.....				
	Whitton's House...	134	590.508	0.636	111.132	Williamson's Isl'd.			
		135	589.985	0.523	.....				
	Sistersville, Va....	136	589.857	0.110	111.783				
		137	589.655	0.220	.....				
		138	589.542	0.113	.....	Well's Island.....	138	5,000	1.10
		139	588.439	1.103	.....				
		140	588.239	0.200	.....	Mill Cr'k Isl'd Bar.	140½	5,200	1.06

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pittsburg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pittsburg.	Shoals and ripples.	Distance of head of ripple from Pittsburg.	Length of ripple.	Fall of ripple.
		Mls.	Feet.	Feet.	Feet.		Miles.	Feet.	Feet.
141½	Matamoras, Ohio ...	141	587.837	0.402	113.803	Grandview Island Bar.	141½	5,000	1.00
		142	586.337	1.500	.....	Grandview Shoals	142½	10,500	1.35
		143	585.577	0.760	.....				
		144	585.144	0.433	.....	Shiftail Riffle	145½	3,000	0.43
		145	584.811	0.333	.....	Petticoat Bar	146½	3,000	1.40
		146	583.773	1.038	.....				
		147	582.673	1.100	.....				
		148	582.419	0.254	.....				
		149	582.204	0.215	.....				
		150	581.984	0.220	.....	Bat and Grape Island.	150½	9,000	0.52
		151	581.524	0.460	120.116	Middle Island.	152	2,800	1.80
		152	580.797	0.627	.....				
154½	St. Mary's, Va.	153	579.342	1.555	.....				
155½	Newport, Ohio.	154	579.292	0.150	122.348				
		155	579.139	0.053	122.295				
		156	579.097	0.042	.....				
		157	578.927	0.170	.....	Three Brothers Is'd	157½	12,200	2.20
		158	577.915	1.012	.....				
		159	576.802	1.113	.....				
160½	Cow Creek, Va.	160	576.090	0.712	125.660				
		161	575.980	0.110	.....				
		162	575.763	0.217	.....				
		163	575.593	0.170	.....	Bull Creek Bar.	163½	2,500	0.52
		164	575.223	0.370	.....	Carpenter's Bar	166	4,500	1.52
		165	574.773	0.450	.....				
		166	574.673	0.109	.....	Marietta Is'd Head	167½	10,500	2.20
		167	573.127	1.546	.....	Duck Creek Bar	.....	14,240	1.53
		168	572.527	0.600	.....				
		169	572.027	0.500	.....				
		170	571.077	0.950	.....				
	Marietta, Ohio.	171	569.821	1.256	131.820				
		172	569.701	0.120	.....				
		173	569.627	0.074	.....	Muskingum Island	173½	26,400	2.65
		174	568.677	0.950	.....				
		175	567.777	0.900	.....				
		176	566.977	0.800	.....				
	Briscoe Run, Va ...	177	566.727	0.250	134.913	Vienna Island	176½	6,600	0.97
		178	565.754	0.973	.....				
		179	565.554	0.200	.....				
		180	565.344	0.210	.....	Coles' Island	180	7,900	1.76
		181	564.534	0.810	.....				
183½	Kanawha River, Parkersburg, Va.	182	563.794	0.740	.....				
		183	563.694	0.100	137.950				
		184	563.530	0.164	.....				
		185	562.805	0.725	.....	Blennerhassett's Island.	184½	21,200	4.62
		186	562.298	0.507	.....				
		187	561.842	0.456	.....				
		188	561.176	0.666	.....				
188½	Wing-dam, foot of Blennerhassett's Island.	189	558.878	2.298	142.762				
		190	558.678	0.200	.....	Little Hockhocking River Bar.	190½	3,500	0.85
190½	Little Hockhocking River, Ohio.	191	558.628	0.650	143.612				
		192	557.938	0.090	.....				
		193	557.838	0.100	.....	Newbury Bar	193	4,000	1.45
		194	556.388	1.450	.....	Mustapha Island	194½	9,200	1.05
		195	555.338	1.050	.....				
		196	555.108	0.230	.....				
197½	Big Hockhocking, Ohio.	197	554.598	0.210	146.742				
		198	554.665	0.233	.....				
		199	554.449	0.216	.....	Lee Creek Bar	199½	3,950	0.94
		200	553.509	0.940	.....				
		201	553.009	0.500	.....				
		202	552.803	0.206	.....	Bellville Bar	202	7,500	2.22
		203	550.603	2.200	.....	Bellville Island	202	5,000	4.60
		204	549.135	1.468	.....				
		205	548.875	0.260	.....				
		206	548.665	0.210	.....				
	Murraysville, Va ..	207	548.475	0.190	153.183				
		208	548.320	0.150	.....				
		209	548.190	0.150	.....				
		210	547.504	0.466	.....				
		211	547.484	0.220	.....				
		212	547.184	0.300	.....				
		213	546.329	0.855	.....				

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
218 $\frac{3}{4}$	Portland, Ohio	214	546.199	0.130	155.441	Buffington Island..	214 $\frac{1}{4}$	9,200	1.32
		215	546.179	0.020	.....				
		216	544.865	1.314	.....				
		217	544.641	0.224	.....				
		218	544.601	0.040	.....				
	Ravenswood, Va.	219	544.431	0.170	157.209	Sand Creek Bar ...	218 $\frac{3}{4}$	6,500	1.23
		220	543.201	1.230	.....				
		221	543.091	0.110	.....				
		222	542.991	0.100	.....				
		223	542.851	0.140	.....				
		224	540.998	1.853	.....				
		225	540.795	0.203	.....				
		226	540.492	0.303	.....	Goose Island and Goslin Bar.	226 $\frac{1}{2}$	13,000	2.03
		227	540.100	0.383	.....				
		228	538.466	1.643	.....				
		229	538.103	0.363	.....				
		230	537.550	0.533	.....				
		231	536.884	0.666	.....				
		232	536.344	0.540	.....	Letard's Island and Falls.	232 $\frac{1}{4}$	7,900	3.16
		233	535.391	0.953	.....	do .....	.....		
		234	532.184	3.207	.....	Weaver's Bar	234	7,500	2.06
		235	531.144	1.040	.....				
248 $\frac{3}{4}$		236	530.121	1.023	.....				
		237	529.584	0.537	.....				
		238	528.712	0.872	.....				
	Graham's Station ...	239	528.502	0.210	173.138				
		240	527.502	1.000	.....				
		241	526.397	1.105	.....	Wolf's Bar	239 $\frac{3}{4}$	3,080	1.90
		242	523.897	2.500	.....	Seegrist's Ripple..	241	6,600	2.50
		243	523.457	0.440	.....				
	Hartford City, Va..	244	522.705	0.752	178.935	Sliding Hill Bar...	243	3,950	0.98
		245	522.362	0.343	.....				
		246	521.926	0.436	.....				
248 $\frac{3}{4}$		247	521.489	0.437	.....				
		248	521.053	0.436	.....				
	Pomeroy, Ohio.	249	520.617	0.436	181.023				
		250	520.184	0.436	.....				
		251	519.749	0.435	.....				
		252	519.430	0.319	.....	Leading Creek Bar.	252	2,500	0.75
		253	518.680	0.750	.....				
		254	518.564	0.116	.....				
		255	518.099	0.465	.....	Eight-Mile Island Bar.	255	9,200	1.24
		256	516.864	1.234	.....				
		257	516.479	0.385	.....				
260 $\frac{1}{2}$		258	516.206	0.273	.....	Six-Mile Island Bar.	258	1,750	0.59
		259	515.620	0.585	.....				
	Campaign Creek, Ohio.	260	515.348	0.273	186.292				
		261	515.074	.....	.....				
		262	514.804	0.270	.....				
		263	514.554	0.250	187.313				
	Big Kanawha River, Va.	264	514.054	0.500	.....	Kanawha Bar.....	264	5,000	1.35
		265	512.704	1.350	.....				
		266	512.454	0.250	.....	Gallipolis Bar.....	266	6,300	1.54
		267	510.914	1.540	190.726				
	Gallipolis, Ohio.	268	510.804	0.110	.....				
263 $\frac{1}{2}$		269	510.704	0.100	.....				
		270	510.604	0.100	.....				
		271	510.154	0.450	.....	Carrion Ripple....	271	2,600	0.36
		272	510.134	0.020	.....				
		273	510.044	0.090	.....				
		274	508.894	1.150	.....				
		275	508.344	0.550	.....				
		276	507.944	0.400	.....				
		277	507.754	0.190	.....				
		278	507.574	0.180	.....				
		279	507.494	0.080	.....				
		280	507.414	0.080	.....				
		281	507.334	0.080	.....				
		282	507.254	0.080	.....				
		283	505.954	1.300	195.686	Eighteen Mile C'k. ....	.....		
		284	505.754	0.200	.....				
	Eighteen-Mile Creek								

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
	Little Guyandotte River.	285	505.154	0.600	196.486	Little Guyandotte River.	484 $\frac{1}{2}$	2,640	0.60
		286	504.954	0.200	.....				
		287	504.654	0.300	.....				
		288	504.354	0.300	.....				
		289	504.154	0.200	.....				
		290	503.954	0.200	.....	Green Bottom Rip- ple.	290	5,000	1.85
		291	502.302	1.652	.....				
		292	501.850	0.452	.....				
	Millersport and Fed- eral Creek, Ohio.	293	501.399	0.451	200.000				
	Haskelville, Ohio. . .	294	500.849	0.450	.....				
		295	500.594	0.255	201.046				
		296	500.344	0.250	.....				
		297	500.079	0.265	.....				
		298	499.817	0.262	.....	Dogham Bar.	298 $\frac{3}{4}$	6,600	1.53
		299	499.154	0.663	.....				
		300	498.288	0.866	.....				
302 $\frac{1}{2}$	Big Guyandotte Riv.	301	497.929	0.359	.....	Guyandotte River.	302 $\frac{1}{2}$	9,200	1.82
		302	497.676	0.253	203.964				
		303	496.820	0.856	.....				
		304	495.854	0.966	.....				
		305	495.179	0.675	.....				
306 $\frac{1}{2}$	Symm's Creek, Ohio.	306	494.504	0.675	207.136				
		307	493.829	0.675	.....				
		308	493.154	0.675	.....	Buffalo Creek Bar.	308 $\frac{1}{2}$	500	1.37
		309	492.451	0.700	.....				
		310	491.654	0.800	.....				
	Burlington, Ohio . . .	311	490.854	0.800	210.786				
	Ceredo, Va.	312	490.054	0.800	211.586	Twelve Pole Bar. .	311	10,500	2.35
		313	488.554	1.500	.....				
314 $\frac{1}{2}$	Big Sandy River, (Kentucky State line.)	314	488.492	0.062	213.148	Big Sandy Shoals. .	314	18,500	2.80
		315	488.232	0.260	.....				
		316	486.869	1.363	.....				
317 $\frac{1}{2}$	Sheridan Coal Works	317	486.506	0.363	215.134				
		318	486.444	0.062	.....				
		319	486.382	0.062	.....				
320 $\frac{1}{2}$	Ashland, Ky.	320	486.220	0.162	215.420				
		321	486.057	0.163	.....	Poak's Shallows. . .	321 $\frac{1}{2}$	10,500	2.50
		322	485.894	0.163	.....				
		323	485.137	0.757	.....				
		324	483.380	1.757	.....				
	Ironton, Ohio.	325	482.934	0.456	218.706				
		326	482.477	0.457	.....				
327 $\frac{1}{2}$	Hanging Rock, Ohio.	327	482.124	0.353	219.516				
		328	481.864	0.260	.....				
329 $\frac{1}{2}$	Union Landing, Ohio	329	481.604	0.260	220.036	Ferguson's Bar . . .	329	25,000	3.80
		330	480.793	0.811	.....				
		331	479.882	0.911	.....				
		332	479.171	0.711	.....				
333 $\frac{1}{2}$	Greenupsburg, Ky. . .	333	478.450	0.721	223.010				
		334	477.734	0.716	.....				
		335	477.419	0.316	.....				
		336	477.104	0.315	.....	Jenatt's Shoals. . . .	336	5,100	2.35
		337	474.754	2.350	.....				
		338	474.274	2.480	.....				
		339	473.789	0.485	.....				
		340	473.505	0.284	.....				
	Burk's Point, Ohio. . .	341	473.221	0.284	228.449				
		342	472.936	0.285	.....				
		343	472.651	0.285	.....				
344 $\frac{1}{2}$	Pine Creek, Ohio . . .	344	472.367	0.284	229.273				
		345	472.083	0.284	.....				
346 $\frac{1}{2}$	Sciotoville, Ohio . . .	346	471.799	0.284	229.841	Little Scioto Bar. .	345 $\frac{3}{4}$	10,500	1.86
		347	470.816	0.938	.....				
		348	469.934	0.882	.....				
		349	469.669	0.265	.....				
		350	469.374	0.295	.....				
	Tiger Creek, Ky. . . .	351	469.091	0.283	232.549	Cub Creek Car. . . .	351 $\frac{1}{2}$	5,200	1.46
		352	468.208	0.883	.....				
353 $\frac{1}{2}$	Portsmouth, Ohio. . .	353	467.526	0.682	234.114				
		354	466.774	0.752	.....				
		355	465.990	0.784	.....				
		356	465.806	0.184	.....				

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
	Portsmouth, Ohio ..	357	465.622	0.184	.....				
		358	465.438	0.184	.....				
		359	465.054	0.384	.....	Turkey Creek Bar	358 $\frac{3}{4}$	7,900	1.03
		360	464.359	0.695	.....				
		361	464.164	0.195	.....				
		362	463.970	0.194	.....				
		363	463.755	0.215	.....				
	Quincy, Ky.....	364	463.561	0.194	238.079	Conscownogue Bar	364 $\frac{1}{2}$	5,250	1.30
		365	462.576	0.995	.....				
		366	461.872	0.695	.....				
		367	461.677	0.195	.....				
368 $\frac{1}{4}$	Rockport, Ky.....	368	461.482	0.195	240.158				
		369	461.292	0.190	.....				
		370	461.102	0.190	.....	Twin Creek Bar...	370	5,200	1.20
	Buena Vista, Ohio..	371	459.902	1.200	241.730				
	Rockville, Ohio.....	372	459.544	0.358	241.380				
		373	459.381	0.163	.....				
		374	459.218	0.163	.....				
		375	459.054	0.164	242.586				
		376	458.940	0.114	.....				
		377	458.814	0.126	.....				
		378	458.689	0.125	.....				
		379	458.164	0.525	.....	Quick's Run bar ..	379	3,950	0.80
		380	457.590	0.574	.....				
380 $\frac{1}{4}$	Rome, Ohio.....	381	457.108	0.482	244.532				
		382	456.826	0.282	.....	Graham's Lower	382	7,800	1.16
		383	456.144	0.682	.....	Station Bar.			
		384	455.664	0.480	.....	Brush Creek Isl'd.	384 $\frac{1}{4}$	5,250	0.90
		385	454.764	0.900	.....				
		386	454.604	0.160	.....				
	Concord, Ky.....	387	454.444	0.160	247.196				
		388	454.284	0.160	.....	Pennyweight's	388 $\frac{1}{2}$	5,200	0.82
388 $\frac{1}{2}$	Wrightsville, Ohio ..	389	453.824	0.460	247.186	Bar.			
		390	453.364	0.460	.....				
		391	453.204	0.160	.....	Manchester Island	391 $\frac{1}{2}$	11,600	2.40
		392	452.634	0.570	.....	Bar.			
		393	451.718	0.916	.....				
	Manchester, Ohio...	394	450.802	0.916	250.838				
		395	450.686	0.116	.....				
		396	450.570	0.116	.....				
		397	450.454	0.116	.....				
		398	450.354	0.100	.....				
		399	450.254	0.100	.....				
	Cabin Creek, Ky ...	400	450.154	0.100	251.486				
		401	450.054	0.100	.....				
		402	449.954	0.100	.....	Brook's Bar.....	402	7,900	1.21
		403	449.290	0.664	.....				
		404	448.740	0.550	.....				
	Maysville, Ky.....	405	448.484	0.256	253.156				
		406	448.344	0.140	.....				
		407	448.244	0.100	.....				
		408	448.144	0.100	.....				
		409	448.044	0.103	.....				
		410	447.940	0.101	.....				
		411	447.838	0.102	.....				
		412	447.154	0.684	.....	Charleston Bar ...	412	6,600	0.68
		413	446.887	0.267	.....				
	Ripley, Ohio.....	414	446.721	0.166	254.919				
		415	446.554	0.167	.....				
216 $\frac{1}{2}$	Levana, or Dover, Ohio.	416	446.387	0.167	255.253				
		417	446.120	0.267	.....				
		418	445.654	0.466	.....	Straight Creek Bar	418	5,000	0.97
		419	445.154	0.500	.....				
		420	444.954	0.200	.....				
421 $\frac{1}{2}$	Higginsport, Ohio..	421	444.754	0.200	256.886				
		422	444.654	0.100	.....				
		423	444.554	0.100	.....				
	Angusta, Ky.....	424	444.354	0.200	257.286	Angusta Bar.....	424	7,900	1.50
		425	443.554	0.800					
		426	442.954	0.600					
	Utopia, Ohio	427	442.487	0.467	259.153				

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		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
	Bull Creek, Ohio ...	428	442.020	0.467	259.610				
		429	441.554	0.466					
		430	441.254	0.300					
	Chilo, Ohio.....	431	440.954	0.300	260.686	Locust Creek Bar. Chilo Reach and Big Snake Bar.	428½	29,000	2.00
		432	440.504	0.450					
		433	440.054	0.450					
		434	439.754	0.300					
	Neville, Ohio, and Foster's Landing, Ky.	435	439.654	0.100	261.986				
		436	439.554	0.100					
		437	439.504	0.050					
		438	439.469	0.035					
	Moscow, Ohio	439	439.426	0.043	262.214				
		440	439.373	0.053					
441½	Pt. Pleasant, Ohio, (birth place of General Grant)...	441	439.340	0.033	262.300				
		442	439.297	0.043					
		443	439.254	0.043					
		444	439.075	0.179					
		445	438.496	0.579		Richmond Bar	444½	7,900	1.25
	New Richmond, Ohio	446	437.919	0.578	263.722				
		447	437.641	0.277					
		448	437.370	0.271					
		449	437.134	0.236					
	Palestine, Ohio.....	450	436.754	0.380	264.886				
		451	436.354	0.400		Nine Mile Bar	451½	13,100	1.20
		452	435.754	0.600					
		453	435.154	0.600					
	Buzzard's Roost, O.	454	434.954	0.200	266.686				
		455	434.754	0.200		Four and Five Mile Bars.	455½	13,000	1.70
		456	434.154	0.600					
		457	433.554	0.600					
		458	433.054	0.500					
459¾	Little Miami River, Ohio.	459	432.854	0.200	268.786				
		460	432.702	0.152					
		461	432.547	0.155					
		462	432.398	0.149		Crawfish and Whet- stone Bars.	462	10,550	0.95
		463	432.046	0.352					
	Jamestown, Ky	464	431.594	0.452	270.056				
		465	431.452	0.242					
466½	Cincinnati, Ohio, suspension bridge.	466	430.800	0.552	270.800				
		467	430.396	0.504					
		468	430.383	0.013					
		469	430.369	0.014					
	Baldface Creek, Sodamsville, Ohio.	470	430.247	0.122	271.393				
		471	429.925	0.322		McCullum's Bar ..	471½	4,700	0.80
		472	429.330	0.595					
473½	Anderson's Ferry, Ky.	473	429.102	0.228	272.538				
		474	428.872	0.230					
		475	428.835	0.037					
		476	428.785	0.050					
476¾	Rapid Run, Ohio ...	477	428.782	0.003	272.858				
	Taylorville, Ky ...	478	428.780	0.102	272.860				
		479	428.704	0.076					
	Muddy Creek, Ohio.	480	428.647	0.057	273.000				
		481	428.580	0.067		North Bend Bar ..	481¾	5,200	0.70
		482	428.423	0.157					
		483	427.872	0.551					
		484	427.756	0.116					
		485	427.539	0.217		Medoc Bar.....	484¾	5,200	0.90
		486	426.854	0.685					
	Big Miami River...	487	426.617	0.237	275.023				
		488	426.415	0.202		Big Miami River, Ohio and Indiana boundary.	486¾	11,800	1.37
	Lawrenceburg, Ind.	489	425.482	0.933	276.158				
		490	425.000	0.482					
	Petersburg Land- ing, Ky.	491	424.901	0.099	276.739				
		492	424.866	0.035					
492¾	Aurora, Ind.....	493	424.621	0.245	277.019				
		494	424.482	0.139		Laughery's Creek Bar.	494½	6,600	1.18
	Laughery's Creek, Ind.	495	423.858	0.624	277.782				
495½	Kerby's Rock	496	423.307	0.551	278.000				
		497	423.300	0.007		Laughery's Island.	497¼	9,200	1.88
		498	421.720	1.580					

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		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
	Kerby's Rock—Con.	499	421.423	0.297					
		500	421.243	0.180					
		501	421.130	0.113	.....				
	Rising Sun, Ind.	502	419.520	1.610	282.120	Rising Sun Bar and Ranty's Shal- lows.	501	15,800	3.52
		503	418.190	1.330	.....				
504½	Arnold's Creek, Ind.	504	417.606	0.584	.....				
		505	417.452	0.154	284.188				
		506	417.190	0.260	.....				
		507	416.781	0.409	.....				
		508	416.347	0.434	.....	Gunpowder Bar...	508	14,500	2.00
509½	Gunpowder Creek, Ky.	509	415.470	0.877	286.070				
		510	414.625	0.845	.....				
		511	413.925	0.600	.....				
512½	Big Bone Creek, Ky	512	413.720	0.205	288.347	Big Bone Creek Bar	512½	5,200	1.05
		513	412.868	0.852	.....				
		514	412.760	8.108	288.880				
514½	Goose Creek, Ind.	515	412.650	6.160	289.040				
	Patriot, Ind.	516	412.530	0.100	.....				
		517	412.460	0.040	.....				
518½	Sagar Creek, Ky ...	518	412.316	0.144	.....				
		519	412.075	0.241	.....				
		520	412.040	0.235	.....				
		521	411.790	0.250	.....				
723½	Bryant's Creek, Ky.	522	411.570	0.220	.....	Potato Patch.	522½	5,200	0.79
523½	Warsaw, Ky.	523	411.000	0.570	.....				
524½	Florence, Ind.	524	410.905	0.035	290.640	Warsaw Bar.	524	10,550	1.12
525½	Craig's Creek, Ky..	525	410.250	0.655	.....				
		526	409.782	0.468	.....				
		527	409.603	0.179	.....				
528½	Stevens's Creek, Ky.	528	409.515	0.188	.....				
	Loglick Creek, Ind.	529	409.310	0.105	.....				
		530	409.280	0.030	.....				
		531	408.677	0.603	.....	Vevay Island Bar.	530	7,900	0.63
		532	408.330	0.347	.....				
	Vevay, Ind., and	533	408.130	0.200	293.510	Vevay Bar.	533	10,550	1.20
	Ghent, Ky.	534	407.610	0.520	.....				
		535	406.940	0.670	.....				
		536	406.665	0.275	.....	Craig's Bar.	630½	7,900	1.75
		537	406.175	0.490	.....				
		538	404.720	1.455	.....				
		539	404.520	0.200	.....				
		540	404.166	0.354	.....				
	Carrolton, mouth of	541	403.828	0.338	297.812				
	Kentucky River.	542	403.705	0.033	.....				
543½	Notch Lock Creek, Ky.	543	403.770	0.025	.....				
	Captain J. Arm- strong's, Ind.	544	403.371	0.399	298.269	Locust Creek Bar.	543½	6,600	1.17
545½	Indiana Key River, Ind.	545	402.600	0.771	299.040				
		546	402.495	0.105	.....				
		547	402.460	0.035	.....				
		548	402.443	0.017	.....				
		549	402.160	0.283	.....	Hongland Bar.	549	10,550	1.35
551½	Eagle Hollow, Ind. .	550	401.750	0.410	299.890				
	Lonesome Hollow, Ind.	551	401.097	0.653	300.543				
		552	400.970	0.127	.....				
552½	East street, Madi- son, Ind.	553	400.826	0.144	300.814				
554½	Ship Yard, Madison, Ind.	554	400.435	0.391	.....				
555½	Clifty Creek, Ind. .	555	400.434	0.001	.....				
		556	400.430	0.004	.....				
557½	Hanover Landing, Ind.	557	400.410	0.020	301.230	Cooper's Bar.	557	11,870	0.93
		558	399.633	0.777	.....				
		559	399.480	0.153	.....				
		560	399.370	0.110	.....				
561½	Reed's L'nd'g. Plow- handle Point, Ind.	561	399.326	0.044	.....				
562½	New London, Ind. .	562	399.283	0.041	302.355				
		563	399.238	0.047					
		564	399.190	0.048					
564½	Big Soliday Creek, Ind.	565	399.150	0.040					

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		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
566½	Corn Creek, Ky	566	399.112	0.038	302.528				
		567	399.030	0.082	.....				
		568	399.020	0.010	.....				
		569	398.810	0.210	.....				
	Bethlehem, Ind.	570	398.678	0.132	302.962				
		571	398.430	0.248	.....				
		572	398.390	0.040	.....				
		573	398.376	0.014	.....				
		574	398.300	0.076	303.340				
		575	398.255	0.045	303.385				
		576	398.183	0.072	.....	Middle Island.	576	10,500	0.65
		577	397.902	0.281	.....				
		578	397.530	0.372	.....	Eighteen-Mile Isl- and.	578	5,200	0.42
580½	Herculaneum, Ind. .	580	397.110	0.056	334.530				
		581	396.570	0.540	.....				
		582	396.070	0.500	.....	Grassy Flats.	581	9,240	1.72
		583	395.393	0.677	.....				
		584	395.336	0.057	.....				
585½	Fourteen-mile Cr'k, Ind.	585	395.298	0.030	.....				
586½	Charleston Land- ing, Ind.	586	395.250	0.048	306.390				
		587	395.227	0.023	.....				
		588	394.885	0.342	.....	Twelve-Mile Isl- and.	587½	10,500	0.69
		589	394.660	0.225	.....				
		590	394.640	0.020	.....				
591½	Utica, Ind.	591	394.590	0.050	.....				
592½	Six-Mile Island.	592	394.585	0.005	.....				
		593	394.576	0.009	.....				
		594	394.560	0.016	.....				
	Louisville City wa- ter-works.	595	394.550	0.010	307.690				
		596	394.536	0.014	.....				
		597	394.534	0.002	.....				
		598	393.300	1.234	308.340	Louisville Falls. .	597½	.....	1.23
		598½	391.034	2.266	310.606	Louisville Falls. .	598½	.....	2.26
		599	376.534	14.500	325.106	Louisville Falls. .	599	.....	14.50
		599½	373.680	2.854	327.960	Louisville Falls. .	599½	.....	2.85
		600	371.434	2.246	330.206	Louisville Falls. .	600	.....	2.25
		601	368.600	2.834	333.040	Silver Creek.	601	.....	2.83
		602	367.600	1.000	334.140	Wharf Boat.	602½	.....	2.05
	New Albany.	603	366.550	1.050	335.090	{ Sand Island, Port- land Bar, and Fall- ing Run Bar. }	603 } 604 }	10,500	1.88
		604	365.500	1.050	336.140				
		605	364.770	0.830	.....				
		606	364.400	0.370	.....				
	Middle Creek, Ind. .	607	364.300	0.100	.....				
		608	364.240	0.060	337.400				
		609	363.817	0.423	.....				
		610	363.400	0.417	.....	Hugh's Bar.	608½	5,200	0.84
	Knob Creek, Ind.	611	363.370	0.030	.....				
		612	363.310	0.060	.....				
		613	363.280	0.030	.....				
		614	362.900	0.389	.....				
		615	362.538	0.362	.....				
		616	362.400	0.138	.....				
		617	361.950	0.450	.....				
	Dean's Woodyard, Ky.	618	361.550	0.450	.....	Christopher's Crossing.	617	6,600	0.95
		619	361.200	0.300	340.440				
		620	360.960	0.240	.....				
		621	360.743	0.217	.....				
		622	360.473	0.270	.....				
	Salt River, Ky.	623	360.320	0.153	.....	Salt River Bar.	623½	5,200	0.90
		624	360.566	0.754	.....				
	Brown's Landing. .	625	359.300	0.266	.....				
		626	358.780	0.520	342.860				
		627	358.307	0.473	.....	Brown's Landing Bar.	625½	6,600	0.72
	New Boston.	628	357.692	0.615	343.948				
		629	357.516	0.176	.....	New Boston Bar. .	627½	6,600	1.09
		630	357.454	0.062	.....				
	Otter Creek.	631	357.390	0.064	344.250				
		632	357.350	0.040	.....				
		633	357.320	0.030	.....				

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		Miles.	Feet.	Feet.	Feet.		Miles.	Feet.	Feet.
642½	Tobacco Landing...	634	356.950	0.370	.....	Moianau's Bar	633½	6,600	0.96
		635	356.358	0.592	345.282				
		636	356.310	0.640	.....				
		637	356.223	0.087	.....				
		638	356.166	0.057	.....				
	Brandenburg, Ky...	639	355.832	0.334	.....	Brandenburg Bar	639	10,500	1.83
		640	355.226	0.606	346.414				
	Muckport	641	354.320	0.906	.....				
		642	354.080	0.240	347.560				
		643	353.838	0.242	.....				
		644	353.674	0.164	.....	Haunted House Bar.	644	5,300	0.53
		645	353.360	0.374	.....				
		646	353.370	0.030	.....	Lower chute of Haunted House Bar.	646	5,200	0.33
		647	353.041	0.329	.....				
		648	353.005	0.036	.....				
	Amsterdam	649	352.970	0.035	.....				
		650	352.938	0.032	348.702				
		651	352.926	0.012	.....				
		652	352.880	0.046	.....				
		653	352.835	0.045	.....				
		654	352.690	0.145	.....	Upper and Lower Blue River Isl- and.	654	18,500	4.00
672½		655	351.646	1.044	.....				
		656	350.170	1.476	.....				
	Leavenworth	657	348.770	1.400	.....				
		658	348.560	0.270	353.140				
		659	348.320	0.180	.....				
	Freedonia	660	348.210	0.110	.....				
		661	348.100	0.110	353.540				
		662	348.000	0.100	.....				
		663	347.950	0.050	.....				
		664	347.900	0.050	353.740	Schooner Point....	663½	6,600	0.38
		665	347.520	0.380	.....				
		666	347.438	0.082	.....				
	Hawkins' Landing..	667	347.356	0.082	.....				
		668	347.152	0.004	354.488	Peckenbaugh's Bar	668½	13,700	0.40
		669	346.980	0.172	.....				
		670	346.748	0.232	.....				
	Wolf Creek	671	346.620	0.128	355.020				
	Little Blue River...	672	346.600	0.020	.....				
	Alton, Ind.	673	346.510	0.090	355.130	Little Blue River Bar.	672½	10,500	0.30
685½ 680½		674	346.315	0.195	.....				
		675	346.280	0.035	.....				
		676	346.267	0.013	.....				
	Reno, Ind	677	346.253	0.014	355.387				
		678	346.240	0.013	.....				
	Hatfield's House ...	679	346.165	0.135	355.535				
		680	345.970	0.135	.....				
	Concordia, Ky	681	345.836	0.134	355.804				
	Davis Landing, Ind	682	345.578	0.258	356.062	Flint Island and Oil Creek Bar.	682	21,100	3.00
	Jas. Elshy, pilot ...	683	345.121	0.457	.....				
		684	343.886	1.235	.....				
	Oil Creek	685	342.840	1.046	.....				
	Derby	686	342.726	0.120	358.920				
		687	342.600	0.120	.....				
		688	342.560	0.100	.....				
		689	342.100	0.460	.....	Yellow Bank Creek	688½	5,250	0.70
	Yellow Tank Creek	690	341.790	0.310	.....				
		691	341.520	0.270	.....				
		692	340.877	0.643	.....	Foot of Shenault's Reach.	692	6,600	1.60
		693	340.792	0.085	.....				
697½		694	340.707	0.085	.....				
	Stevensport	695	340.622	0.085	361.018				
		696	340.537	0.085	.....				
	Bear Creek	697	340.467	0.070	.....	Holtz's Bar	697½	6,600	0.32
		698	340.145	0.322	.....				
		699	340.066	0.079	.....				
		700	340.064	0.062	.....				
		701	339.940	0.064	.....				
		702	339.880	0.060	.....				
	Gregory's, Ky	703	339.818	0.062	361.822				
		704	339.752	0.066	.....				
	Cloversport, Ky	705	339.687	0.065	361.953	Clover River Bar...	704½	7,900	0.30

Table exhibiting elevation above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
710½	Faucett's Creek	706	339.538	0.149		Hog's Point Bar ..	709	13,200	1.02
		707	339.470	0.060	.....				
		708	339.287	0.183	.....				
		709	339.068	0.219	.....				
	Millstone Creek	710	338.619	0.449	.....				
		711	338.260	0.359	.....				
		712	338.073	0.187	.....				
		713	337.986	0.087	.....				
		714	337.943	0.043	.....				
		715	337.813	0.130	.....				
	Hawsville	716	337.693	0.120		Troy Reach	718	31,680	1.90
		717	337.553	0.140	364.087				
		718	337.369	0.184	.....				
		719	337.047	0.322	.....				
	Fell City, Ind.	720	336.783	0.264	364.857	Anderson's Bar ...	727½	23,700	2.86
735½		721	336.419	0.364	.....				
		722	336.113	0.306	.....				
		723	335.763	0.350	.....				
	Troy, Ind	724	335.413	0.350	366.127				
		725	335.263	0.150	.....				
		726	335.079	0.184	.....				
		727	334.895	0.184	.....				
		728	334.411	0.484	.....				
		729	333.827	0.584	.....				
		730	333.243	0.584	.....				
	Lewisport	731	332.659	0.584	368.981				
		732	332.175	0.484	.....				
		733	331.891	0.284	.....				
		734	331.609	0.282	.....				
	Grandview	735	331.468	0.141	370.172	Rockport Bar	736½	21,100	1.16
738½		736	331.336	0.132	.....				
		737	331.087	0.249	.....				
	Honey Creek	738	330.748	0.339	.....				
		739	330.409	0.339	.....				
740½	Rockport, Ind	740	330.173	0.236	371.467	Ruppy Creek and Yellow Bank Is'd Bars.	743½	18,480	1.30
		741	330.003	0.070	.....				
		742	329.853	0.150	.....				
		743	329.693	0.160	.....				
		744	329.533	0.160	.....				
		745	329.033	0.500	.....				
		746	328.535	0.498	.....				
		747	328.394	0.141	.....				
		748	328.253	0.141	.....				
	Owensboro, Ky.	749	328.113	0.140	373.527	Bon Harbor Bar ...	249½	10,500	0.80
		750	327.774	0.339	.....				
		751	327.318	0.456	.....				
	Bon Harbor, Ind ...	752	327.063	0.255	374.577				
755½		753	326.607	0.456		Little Hurricane Island.	753	13,200	1.72
		754	326.151	0.456	.....				
	Enterprise	755	325.737	0.414	375.903				
		756	325.613	0.124		French Island	756½	28,900	2.43
		757	325.146	0.467	.....				
		758	324.580	0.566	.....				
	Point Isabel	759	324.013	0.567	377.060				
		760	323.829	0.184		Scaffoldtown Bar ...	764½	18,450	2.31
		761	323.529	0.300	.....				
		762	323.170	0.359	.....				
		763	323.113	0.057	.....				
		764	323.053	0.060	.....				
		765	322.475	0.578	.....				
	Pigeon Creek, Ind..	766	321.897	0.578	379.743				
		767	321.321	0.576	.....				
		768	320.743	0.578	.....				
767½ 769½	Cypress Creek, Ind.	769	320.491	0.252	381.149				
	Newburg, Ind	770	320.366	0.105	.....				
		771	320.251	0.135		Three Mile Island.	771	18,450	1.20
		772	319.946	0.305	.....				
		773	319.570	0.376	.....				
		774	319.168	0.402	.....				
	Green River, Ky.	775	319.056	0.112	382.584	Green River Tow- head.	776	16,500	0.50
		776	318.893	0.163	.....				
		777	318.634	0.259	.....				
		778	318.375	0.259	.....				

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.	
		<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>	
794½	Evansville, Ind.	778	318.456	0.178		Evansville Bar.	782	10,500	0.72	
		779	318.376	0.080	.....					
		780	318.297	0.079	.....					
		781	318.234	0.063	.....					
		782	318.071	0.163	.....					
		783	317.808	0.263	383.832					
		784	317.513	0.295	.....					
		785	317.462	0.051	.....					
		786	317.461	0.001	.....					
		787	317.413	0.048	.....					
	Henderson, Ky.	788	317.361	0.052		Henderson's Bar ..	791	10,500	1.69	
		789	317.298	0.063	.....					
		790	317.236	0.062	.....					
		791	317.184	0.052	.....					
		792	316.861	0.323	.....					
		793	316.537	0.324	.....					
		794	316.467	0.070	385.173					
Henderson, Ind.	795	316.377	0.090		Henderson Island Bar.	796	13,100	1.79		
	796	316.188	0.189	385.452						
	797	315.393	0.795	.....						
	798	314.498	0.895	.....						
	799	314.203	0.295	.....						
	800	314.007	0.196	.....						
	801	313.813	0.194	.....						
	802	313.618	0.195	.....						
	803	313.433	0.185	.....						
	804	313.243	0.190	.....						
807½	West Franklin.	805	312.627	0.616		Diamond Island ...	809¼	13,100	1.76	
		806	312.439	0.188	.....					
		807	312.243	0.196	389.397					
		808	312.075	0.168	.....					
		809	311.513	0.562	.....					
		810	311.063	0.450	.....					
		811	310.563	0.500	.....					
		812	310.313	0.250	.....					
		813	310.170	0.143	.....					
		814	309.727	0.443	.....					
	Mt. Vernon.	815	309.383	0.344		Head of Walnut Bend.	813½	34,300	2.79	
		816	309.039	0.344	.....					
		817	308.560	0.479	.....					
		818	308.047	0.513	393.593					
		819	307.533	0.504	.....					
		820	307.381	0.152	.....					
		821	307.309	0.072	.....					
812½	Louisiana Rocks ... Uniontown.	822	307.247	0.062		Foot of Vernon Bar. Slim Island.	820	26,400	0.90	
		823	307.095	0.152	.....					
		824	306.943	0.152	.....					
		825	306.790	0.153	.....					
		826	306.638	0.152	.....					
		827	306.427	0.211	.....					
		828	306.336	0.091	.....					
		829	306.145	0.191	.....					
		830	305.953	0.192	.....					
		831	305.821	0.132	395.819					
	Lower Highland Rocks.	832	305.680	0.141	395.960	Lower Highland Rock.	833	7,900	0.70	
		833	305.529	0.151	.....					
		834	305.177	0.352	396.463					
		835	304.825	0.352	.....					
		836	304.673	0.152	.....					
		837	304.493	0.180	.....					
		838	304.313	0.180	397.327					
843¼	Wabash River, (Ill. & Ind. boundary.)	839	303.963	0.350		Wabash Island. Wabash Island. Wabash Island. Wabash Island. Wabash Island.	836	36,000	3.82	
		840	303.608	0.355	.....					
		841	303.133	0.475	.....					
		842	302.643	0.490	.....					
	Raleigh.	843	302.273	0.370	399.367	Wabash Island.				
		844	301.913	0.360	.....					
		845	301.548	0.365	.....					
		846	301.180	0.368	.....					
		847	300.815	0.365	400.825					
		848	300.450	0.365	.....					
	847½	Shawneetown, Ky. ..	849	300.200	0.250			848	10 miles	5.07

Table exhibiting elevations above tide, fall for every mile. &c.—Continued.

	Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
		Mls.	Feet.	Feet.	Feet.		Miles.	Feet.	Feet.
849 $\frac{1}{2}$	Coal Banks.....	850	299.943	0.257	401.697				
		851	299.688	0.255	.....				
		852	299.453	0.235	.....				
		853	299.218	0.235	.....				
		854	298.990	0.228	.....				
		855	298.763	0.227	.....				
		856	298.533	0.230	.....				
856 $\frac{1}{2}$	Saline River, Ill....	857	298.048	0.485	.....				
		858	297.563	0.485	.....				
	Schotwell's Coal B'k	859	297.073	0.490	.....				
860 $\frac{1}{2}$	Caseyville.....	860	296.588	0.485	405.052				
		861	296.198	0.390	.....				
	Treadwater River..	862	295.911	0.287	.....				
		863	295.686	0.225	.....				
864 $\frac{1}{2}$	Weston.....	864	295.479	0.207	406.161				
		865	295.273	0.206	.....				
	Ford's Ferry.....	866	295.066	0.207	406.574				
		867	294.859	0.207	.....	Cave in Rock Isl'nd	867 $\frac{1}{2}$	.....	.....
		868	294.653	0.206	.....				
	Cave in Rocktown..	869	294.446	0.207	407.194				
		870	294.239	0.207	.....				
		871	294.023	0.216	.....				
		872	293.233	0.790	.....				
		873	292.443	0.790	.....	Big Hurricane Is- land.	872	31,000	4.27
		874	291.651	0.692	.....				
		875	290.959	0.692	.....				
		876	290.868	0.691	.....				
	Elizabethtown.....	877	290.353	0.515	411.287				
		878	290.337	0.016	.....				
		889	290.322	0.015	.....				
879 $\frac{1}{2}$	Roseclair, Ill.....	880	290.306	0.016	411.334				
881 $\frac{1}{2}$	Carrsville.....	881	290.256	0.050	411.384	Irish Jimmy's Bar	880 $\frac{1}{2}$	7,900	0.24
		882	290.066	0.193	.....				
		883	290.016	0.050	.....	Grand Pierre Cr. Bar.	883 $\frac{1}{2}$	7,900	0.35
		884	289.892	0.124	.....				
		885	289.671	0.221	.....				
		886	289.650	0.021	.....				
		887	289.629	0.021	.....				
		888	289.608	0.021	.....	Golconda Island..	888	.....	.....
		889	289.587	0.021	.....				
	Golconda.....	890	289.566	0.021	412.074				
		891	289.240	0.326	.....				
		892	288.903	0.337	.....				
		893	288.515	0.388	.....	Prior Island.....	893	15,700	1.05
		894	288.287	0.228	.....				
		895	288.063	0.224	.....				
		896	287.796	0.267	.....	Sister's Island....	896	10,500	0.60
		897	287.629	0.167	.....				
		898	287.463	0.166	.....				
	Bay City, Ill.....	899	287.396	0.067	414.244				
		900	287.329	0.067	.....				
		901	287.263	0.066	.....	Head of Stewart's Island.	.....	.....	.....
		902	287.096	0.167	.....				
		903	286.929	0.167	.....				
		904	286.763	0.166	.....				
		905	286.596	0.167	.....				
		906	286.423	0.173	.....	Dry Island.....	906	58,000	2.60
		907	286.183	0.240	.....				
	Smithland, Ky.....	908	285.960	0.223	415.680				
909 $\frac{1}{2}$	Pull light, or west..	909	285.742	0.218	415.898				
		910	285.523	0.219	.....				
		911	285.320	0.203	.....				
		912	285.120	0.200	.....				
		913	284.913	0.207	.....				
		914	284.673	0.240	.....				
		915	284.433	0.240	.....				
		916	284.203	0.230	.....				
		917	283.973	0.230	.....				
		918	283.863	0.010	.....				
		919	283.803	0.060	.....				
	Paducah, Ky.....	920	283.706	0.097	417.934				
		921	283.623	0.083	.....				
		922	283.573	0.050	.....				

Table exhibiting elevations above tide, fall for every mile, &c.—Continued.

Place.	Distance from Pitts- burg.	Elevation of low water above ocean tide.	Fall per mile.	Total fall from Pitts- burg.	Shoals and ripples.	Distance of head of ripple from Pitts- burg.	Length of ripple.	Fall of ripple.
	<i>Mls.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>		<i>Miles.</i>	<i>Feet.</i>	<i>Feet.</i>
Brooklyn, Ill	923	283.525	0.048	418.115				
	924	283.476	0.049	.....				
	925	283.435	0.041	.....				
	926	283.393	0.040	.....				
	927	283.353	0.040	.....				
	928	283.320	0.033	.....				
	929	283.301	0.019	418.329				
	930	283.195	0.106	.....				
	931	283.028	0.167	.....	Little Chain	931 $\frac{1}{4}$	27,000	1.54
	932	282.736	0.292	.....				
	933	282.451	0.285	.....				
	934	282.166	0.285	.....				
	935	281.773	0.393	.....				
	936	281.484	0.293	.....				
	937	281.299	0.181	.....				
Hillerman's, Ill	938	281.230	0.069	.....				
	939	281.160	0.070	420.480				
	940	281.093	0.067	.....				
	941	280.394	0.099	.....				
	942	280.380	0.614	.....				
	943	279.761	0.619	.....	Head Grand Chain.	943 $\frac{1}{4}$	27,000	3.69
	944	279.140	0.621	.....				
	945	278.734	0.406	.....				
	946	278.609	0.125	.....				
	947	278.039	0.570	.....	Foot Grand Chain.	.....	.....	.....
Caledonia, Ill	948	277.405	0.635	.....				
	949	277.203	0.202	.....				
	950	277.000	0.203	.....				
	951	276.850	0.150	424.790				
	952	276.756	0.094	.....				
	953	276.662	0.094	.....				
	954	276.568	0.094	.....				
	955	276.474	0.094	.....				
Mound City, Ill	956	276.380	0.094	.....	Caché Island	956	15,840	0.38
	957	276.186	0.194	.....				
	958	276.092	0.094	.....				
	959	276.000	0.092	425.640				
	960	275.918	0.082	.....				
	961	275.810	0.108	.....				
	962	275.680	0.130	.....				
	963	275.606	0.074	.....				
Cairo, Ill	964	275.452	0.150	426.188				
	965	275.338	0.114	.....				
	966	275.244	0.094	.....				
	967	275.000	2.444	426.640				

Table exhibiting the number and length of pools in the Ohio River showing a depth of seven feet or over at low water.

Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.	Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.	Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.	Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.	Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.	Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.	Total distance from Pittsburg to head of pools.	Length of pools 7 feet and over; depth at low water.
Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
1 $\frac{1}{2}$	1	352 $\frac{1}{2}$	1	100 $\frac{1}{2}$	1	510 $\frac{1}{2}$	2	194 $\frac{1}{2}$	$\frac{1}{2}$	647	7		
4	1 $\frac{1}{2}$	360	4	102	4 $\frac{1}{2}$	513	9	196	3	657 $\frac{1}{2}$	6		
9	1 $\frac{1}{2}$	366 $\frac{1}{2}$	4	108	1	523	1 $\frac{1}{2}$	200 $\frac{1}{2}$	1 $\frac{1}{2}$	664 $\frac{1}{2}$	4		
12 $\frac{1}{2}$	1	371 $\frac{1}{2}$	7	110	11 $\frac{1}{2}$	526	4 $\frac{1}{2}$	203	6	669	3 $\frac{1}{2}$		
15	2	380	1 $\frac{1}{2}$	113	2	531	2	210 $\frac{1}{2}$	$\frac{1}{2}$	673	9		
17 $\frac{1}{2}$	1	385 $\frac{1}{2}$	7	115	2	533 $\frac{1}{2}$	$\frac{1}{2}$	213	1	686	2 $\frac{1}{2}$		
19 $\frac{1}{2}$	4	394	8	117 $\frac{1}{2}$	1 $\frac{1}{2}$	536	1	216	3	692	5		
23	1	403 $\frac{1}{2}$	7 $\frac{1}{2}$	119 $\frac{1}{2}$	1	538	1 $\frac{1}{2}$	220	3	699	9 $\frac{1}{2}$		
34	1	412	5	122	3	541	3	224 $\frac{1}{2}$	1	711	7		
37	1 $\frac{1}{2}$	419	6	125 $\frac{1}{2}$	1	545	4 $\frac{1}{2}$	227	$\frac{1}{2}$	718 $\frac{1}{2}$	2 $\frac{1}{2}$		
39	1 $\frac{1}{2}$	426 $\frac{1}{2}$	3	128	4 $\frac{1}{2}$	551	1	229	4	722	5 $\frac{1}{2}$		
43	3 $\frac{1}{2}$	434	19	134 $\frac{1}{2}$	3 $\frac{1}{2}$	552 $\frac{1}{2}$	5	235 $\frac{1}{2}$	4 $\frac{1}{2}$	729	1 $\frac{1}{2}$		
48	1	447	4 $\frac{1}{2}$	139	1	558	12	242	13	731	7 $\frac{1}{2}$		
50 $\frac{1}{2}$	1	454	1	148	2 $\frac{1}{2}$	571	7	255	1 $\frac{1}{2}$	740 $\frac{1}{2}$	3		
55	1	458	5 $\frac{1}{2}$	151 $\frac{1}{2}$	$\frac{1}{2}$	579	2 $\frac{1}{2}$	257 $\frac{1}{2}$	5 $\frac{1}{2}$	746	4		
57	3	464	1	153	4 $\frac{1}{2}$	589	5 $\frac{1}{2}$	263 $\frac{1}{2}$	1	750 $\frac{1}{2}$	3		
64	1	467 $\frac{1}{2}$	3 $\frac{1}{2}$	160	3 $\frac{1}{2}$	588	11	265	1	755	1 $\frac{1}{2}$		
66	1 $\frac{1}{2}$	471 $\frac{1}{2}$	10 $\frac{1}{2}$	164	1	605 $\frac{1}{2}$	3	267	6	894	1 $\frac{1}{2}$		
68	1	482 $\frac{1}{2}$	2 $\frac{1}{2}$	167	1	614	2	275	7	896	9 $\frac{1}{2}$		
73	1	757 $\frac{1}{2}$	2 $\frac{1}{2}$	170 $\frac{1}{2}$	3 $\frac{1}{2}$	817	5	283	1 $\frac{1}{2}$	907 $\frac{1}{2}$	$\frac{1}{2}$		
76	$\frac{1}{2}$	762	2	176 $\frac{1}{2}$	$\frac{1}{2}$	822 $\frac{1}{2}$	3 $\frac{1}{2}$	288	1	908 $\frac{1}{2}$	1		
79	1 $\frac{1}{2}$	765	1	176	1	826 $\frac{1}{2}$	7	291	2	912	2		
87	1 $\frac{1}{2}$	768	46	182	3	834	6	299 $\frac{1}{2}$	7	916	4		
91	1	774	2 $\frac{1}{2}$	189	1	841	4	610	6 $\frac{1}{2}$	921	13		
93	$\frac{1}{2}$	777	5 $\frac{1}{2}$	485 $\frac{1}{2}$	2	847 $\frac{1}{2}$	5	618	1	933	6		
313	1	783 $\frac{1}{2}$	3 $\frac{1}{2}$	488 $\frac{1}{2}$	6	854	5	621 $\frac{1}{2}$	1 $\frac{1}{2}$	948 $\frac{1}{2}$	8		
317 $\frac{1}{2}$	4 $\frac{1}{2}$	788	8	495	2	861	1	624 $\frac{1}{2}$	1 $\frac{1}{2}$	960	7		
327	2	798	1	497 $\frac{1}{2}$	$\frac{1}{2}$	864 $\frac{1}{2}$	5 $\frac{1}{2}$	628	5 $\frac{1}{2}$	.....	.....		
334 $\frac{1}{2}$	1 $\frac{1}{2}$	800	9	499	2	874	2 $\frac{1}{2}$	635	5	.....	.....		
339	1	810	1 $\frac{1}{2}$	501 $\frac{1}{2}$	$\frac{1}{2}$	877	15 $\frac{1}{2}$	641	1	.....	.....		
341	5	812	1 $\frac{1}{2}$	502 $\frac{1}{2}$	$\frac{1}{2}$	192	1	643	1 $\frac{1}{2}$	.....	.....		
348	2	96 $\frac{1}{2}$	3	504	5 $\frac{1}{2}$	193 $\frac{1}{2}$	1	645	1	.....	.....		

The number of pools in Ohio River over 7 feet in depth at low water, 187. Total length of pools, 632 $\frac{1}{2}$ miles; average length of pools, 3.47 miles. One hundred and twenty-seven pools above Louisville average 2.8 miles, with a total length of 363 miles; 60 pools below Louisville, with total length of 266 miles, averaging 4.4 miles in length.

PITTSBURG. February 15, 1870.

SIR: I have the honor to submit the following statements, tables, comparisons, remarks, &c., on the subject of downfall of rain and the flowage of the Ohio River for such periods as we have records, &c., and such other miscellaneous information as may be valuable for future reference.

Early in November, 1867, a rain-gauge was furnished by the Department at Washington for the use of this office. Upon its receipt, you appointed W. M. Wolcott as hydrographer, to take it in charge and to note such facts of the weather, temperature, and daily depths of the river as was convenient. Since that time the records have been kept by Mr. Wolcott and others until the present date.

In March, 1868, I was directed by yourself to gauge the Allegheny and Monongahela rivers, then in a high stage; to note the flowage of the Ohio in cubic feet per minute, and to measure it frequently at its fall, &c., in order to prepare a table of flowage, &c., representing the amount of water passing per minute or per day at any stage. In a report to you, dated May 22, 1868, there was given an account of those operations, with accompanying approximate table of flowage. Since then a number of revisions and corrections of those figures have been made, and with the data now at hand some valuable results can be presented.

Downfall of rain.

For purposes of comparison, Mr. Wolcott visited the United States arsenal, between 39th and 40th streets, (Lawrenceville,) to get the records of the rain-gauge kept there, for as many years as possible.

It appeared there was much confusion in the records, and we were only able to get a complete record from the beginning of 1867. I believe that the Government records, which I understand were under charge of the Surgeon General's Office, have been greatly neglected at all the posts since the war began—1861.

In a table from the Army Meteorological Register, the average annual fall of rain is given for twenty-two years, from 1822 to the close of 1844, from a number of military posts. The annual rain-fall in that period for the Allegheny arsenal is given therein at 34.96 inches. The only other points in that table which may at all be considered to come under similar atmospheric conditions are Fort Niagara, which is given as 30.88 inches; Carlisle barracks, 34.01 inches; Jefferson barracks, 37.83 inches, and Detroit, 30.07 inches. There are outlying stations to the east, north, and west of the basin of the Ohio—not one of them in the basin; but still they are in situations which will aid in arriving at a tolerably correct average annual rain-fall for this area, were none other attainable.

General A. A. Humphreys presents, on a map accompanying his elaborate report on the physics and hydraulics of the Mississippi River, the following average figures of rain-fall of points within the basin of the Ohio River: Huntsville, Alabama, 54.9; Nashville, Tennessee, 53.9; Evansville, Indiana, 42.8; Louisville, Kentucky, 48.1; Germantown, Indiana, 38.9; north of Cincinnati, 47.1; Newport, Kentucky, 45.9; Portsmouth, Ohio, 38.2; Marietta, Ohio, 44.6; Steubenville, Ohio, 37.3; Hudson, Central Ohio, 33.6; Pittsburg, Pennsylvania, 34.8—*average Ohio River basin*, 43.3. These twelve points are tolerably well distributed; though I have no doubt could more points, to average the area better, have been added to the southern side of the river, the whole average would have been somewhat greater. Probably 45 inches per annum is more correctly the average downfall of rain in the Lower Ohio Valley. Exclusive of the Cumberland and Tennessee River basins, which come in at such a short distance above the mouth of the Ohio, the average downfall of rain for the remainder of the basin, as high as Pittsburg, is probably 41 inches per annum.

The following table exhibits the rain-fall, as noted, for one year, beginning November 1, 1867, Office Ohio River Improvement, Custom-house, Pittsburg, and the Allegheny Arsenal, Pittsburg.

[illegible]

Total rain-fall for the year ending October 31, 1868:

Office Ohio River improvement.....	24.89½ inches.
United States arsenal, Lawrenceville	25.36 inches.

Owing to the absence of Mr. Wolcott at various times, particularly during the month of May, and from other causes of neglect, our record is not complete. I have, after carefully reviewing the matter in connection with my own reliable weather notes, added to the days neglected in our own, but noticed in the arsenal record, the additional rain-fall. These additions we marked in red. From the two records, therefore, it would appear that the rain-fall amounted to 29.19 inches, made by adding the figures in red to the office record, or say 30 inches rain-fall for the year, which latter figure I believe will include all. At the arsenal the amount of melted snow is not added, which fortunately appears in our own. For greater convenience, the following revised and extended table of rainy days, taken from the above list as noted, and our own more correct records since, is given from January 1st, 1868, to January 1st, 1870, (two years.)

Rainy days from 1868 to 1870.

Days of month.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.
1.	.75	1.60					.30	.40	.45	.63		.50					.28		.92	1.30				
2.	.15				.16		.30		.30				.27		.26	.34			1.94					
3.		.10			.04		.05		.40		.15				.44	1.62						.83	.46	
4.									.50		.68		.50				.34	1.75						
5.	.11				.17		.09	.09	.25	.04			.15	.14	.28		.81	.09	.10					
6.	.46						.60						.15	.51			.58							
7.	.69	.12	.64	.07	.11	1.27	.05	.05	.65		.65		.37	.11	.73		.73		.45					
8.					.23	.07	.41		.60	.03		.63	.90				.66							
9.		2.65					.15	.40									.18							
10.					.08		.65		.65						.20									1.05
11.	.92	.04	.03	.08	.40		.64		.10		.16		1.05		.15	.04					.35			
12.					.30		.17	.17	1.60				1.37								.77			.25
13.		.65		.15																				
14.							.01	.08	.70	.20	.83				.34							.60	.72	
15.					.40				.08		.62	.39					.38	.34	.28		.07	.04		
16.									.05	.10			.06		.36						.25	.29		
17.					.31		.06																	
18.																								
19.																								
20.																								
21.																								
22.																								
23.	.19		.41		.31		.05				.10													
24.					.35																			
25.		.30											.10	.14			1.40	.14						.34
26.					.90	.47		.62					.04				.16	1.30						
27.	.10						.18	.40																
28.	.67				.36		.27	.08	.23		.40		.65		.14						.42	.41	.04	
29.							.38	.07	.15		.52		.39		.48							.75		
30.											.38	.19	.52						.40					
31.					.22				.30															
Total inches...	2.14	3.96	2.085	2.83	2.30	3.44	1.84	1.10	3.24	3.18	1.46	3.29	2.28	5.56	1.47	1.08	6.17	5.37	2.44	1.02	3.61	1.80	2.18	2.82

The following table exhibits the monthly rain-fall for 1868 and 1869 for Pittsburg; Franklin, Venango County, one hundred and thirty miles up the Alleghany River, (record furnished by Rev. M. A. Tolman;) and Canonsburg, Washington County, Pennsylvania, (record furnished by Mr. William Smith:)

Year.	January.			February.			March.			April.		
	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.
1868.....	2. 14	2. 665	.....	2. 08	1. 530	.....	2. 30	3. 760	.....	1. 84	2. 540	.....
1869.....	3. 96	4. 670	3. 92	2. 83	2. 050	2. 70	3. 44	3. 865	4. 45	1. 10	0. 150	1. 57
Year.	May.			June.			July.			August.		
	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.
1868.....	2. 24	3. 155	.....	1. 46	.....	1. 800	2. 28	4. 060	.....	1. 47	3. 336	.....
1869.....	3. 18	5. 330	5. 08	3. 89	5. 60	2. 840	5. 56	4. 210	*5. 25	1. 63	1. 350	5. 82
Year.	September.			October.			November.			December.		
	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.	Pittsburg, Pa.	Canonsburg.	Franklin.
1868.....	6. 17	7.960	4. 88	2. 44	1. 520	2. 68	2. 01	2. 960	4. 45	2. 18	1. 690	3. 07
1869.....	5. 37	5.690	†1. 019	1. 02	2. 000	1. 97	1. 80	2. 350	4. 52	2. 82	2. 330	4. 12
										1868.	1869.	
Total rain-fall at Pittsburg										30. 61	36. 600	
Canonsburg										37. 046	36. 835	
Franklin											53. 250	

* Record only to 19th.

† September 7 and 8, rained 7.20 inches.

Mr. Smith also furnished us with the following table of monthly rain-fall for Canonsburg, Pennsylvania. Covering as it does a period of twenty-five years, it is particularly valuable in arriving at the average quantity of rain falling in the valley of the Monongahela. The regularity, persevering, and systematic attention given to the matter by Mr. Smith for so many years, entitles him to much credit. His record is undoubtedly the most correct, interesting, and valuable one kept in this part of the country.

Table of monthly rain-fall, in inches, for *Canonsburg*, from *February, 1845, to January, 1870.*

Months.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.
January.....	1.060	2.606	2.210	1.503	1.730	3.285	.....	1.590	0.965	0.903	2.313	3.165	1.608
February.....	2.925	2.065	3.030	2.640	1.420	2.000	2.130	2.670	3.416	1.530	1.164	1.041	1.910
March.....	2.216	2.542	1.440	1.655	2.470	2.390	1.400	2.050	0.016	2.940	2.731	2.731	1.293
April.....	1.115	4.091	2.420	5.760	3.255	1.650	1.300	0.951	3.956	3.875	2.890	3.621	5.365
May.....	3.301	3.975	4.420	2.912	4.363	2.960	3.497	2.986	3.110	1.860	1.640	2.897	5.730
June.....	3.575	2.050	6.255	6.355	1.060	3.070	2.151	3.295	1.280	0.650	0.630	3.176	5.485
July.....	1.185	9.204	1.870	2.385	3.055	1.400	1.035	2.781	3.003	1.010	7.630	1.050	4.454
August.....	5.508	2.940	3.890	2.170	0.555	2.660	2.158	2.881	0.627	1.505	1.890	1.373	4.488
September.....	5.700	4.785	2.430	1.590	3.695	2.490	0.916	1.871	2.140	2.290	1.950	1.675	2.340
October.....	3.120	2.112	5.420	1.570	4.125	1.580	4.020	3.553	2.960	1.430	4.214	2.110	3.610
November.....	0.190	4.440	5.393	2.785	3.392	3.620	0.825	4.282	0.553	1.600	2.412	1.540	3.730
December.....	27.545	40.810	39.608	31.588	32.720	30.985	23.713	39.479	25.456	20.803	41.906	25.069	3.500
Total.....													43.333

Months.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.
January.....	0.720	1.350	2.180	2.030	6.145	3.865	1.620	2.830	1.760	0.970	2.665	4.670
February.....	1.500	2.686	1.431	2.970	1.840	4.140	1.363	1.380	2.540	1.2.860	1.530	2.050
March.....	0.300	3.965	0.925	1.435	2.070	3.152	3.041	3.100	3.240	4.010	3.760	3.865
April.....	2.925	6.814	3.917	3.915	5.515	2.467	2.642	2.195	.....	1.365	2.540	0.150
May.....	7.580	3.350	3.160	2.055	2.891	1.215	2.242	4.650	1.065	5.100	3.155	5.330
June.....	4.580	3.380	1.515	4.250	3.608	2.785	4.333	6.650	4.792	1.970	0.850	2.840
July.....	2.315	3.215	3.435	5.290	2.745	3.100	2.830	5.614	3.710	3.600	0.850	4.210
August.....	1.268	5.393	4.927	1.344	1.109	1.850	4.675	4.290	3.450	1.835	3.336	1.350
September.....	1.330	3.660	2.650	5.995	0.070	4.898	8.545	4.595	5.350	1.155	7.900	5.690
October.....	2.150	1.160	6.920	2.351	1.965	2.355	1.924	3.065	4.055	2.837	1.530	2.000
November.....	2.819	1.560	4.220	3.944	1.933	2.764	3.980	0.700	3.435	1.183	2.960	2.350
December.....	4.100	3.000	2.150	0.921	1.685	1.490	3.760	2.895	3.130	2.870	1.690	2.330
Total.....	31.587	39.233	39.430	36.463	31.606	33.584	39.955	43.904	36.527	29.776	36.046	36.835

Average annual rain-fall for twenty-five years, Canonsburg, Pennsylvania, 34.331 inches.

DRAINAGE—UPPER OHIO RIVER.

The Alleghany River drains, as near as may be, 12,900 square miles of territory, and the Monongahela 7,000 square miles, making the total area drained by the Ohio at Pittsburg 19,900, or, in round numbers, 20,000 square miles.

The drainage area at Wheeling, 90 miles below Pittsburg, is estimated to be about 25,000 square miles. There is doubtless more rain-fall about the headwaters of the Alleghany and Monongahela Rivers than at points farther down, and also a greater percentage of the water falling in the mountain regions must be discharged by the rivers. The average of rain-fall at Pittsburg is given for a period of twenty-two years, from 1829 to 1845, at 34.96 inches; that at Canonsburg, Pennsylvania, is given for a period of twenty-five years, at 34.331 inches, (1845 to 1870.)

It is generally assumed that the average of rain-fall in the basin of the Ohio above Pittsburg is about 36 inches per annum, which would give 1,672,704,000 cubic feet of water on the 20,000 square miles embraced in that area. Our river record for 1868 shows that 1,342,605,725,800 cubic feet, and in 1869 1,634,846,499,200 cubic feet of water passed Pittsburg. There can scarcely be any doubt of the fact that the rain-fall at the headwaters of both the Alleghany and Monongahela Rivers, in 1868 and 1869, was considerably over the average of 36 inches. During 1869 probably not less than 44 inches of rain fell in this district, making 2,044,516,000,000 cubic feet of total downfall. Our tables, nevertheless, appear to show a much larger ratio of discharge to downfall for this region than is shown by Ellet for Wheeling, or General Humphreys for any of the tributaries of the Mississippi. The fall of the river at Pittsburg is so much greater than the rivers at the points where those engineers measured it, that considerable allowance must be made in favor of a greater ratio of discharge to downfall. In mountainous or hilly countries, where there is no general cultivation, a greater percentage of the rain-fall will find its way into the streams, and where the fall is great will pass down before much is lost by soakage, to be finally evaporated.

The subjoined tables of calculated discharge of the Ohio River, at Pittsburg, from the limited time and opportunity of studying and arranging them, may not be so complete as they could have been made. They furnish correct records of all the heights of the river for two years, however, and may prove valuable for testing and comparing calculations in the future.

THE BASIN OF THE OHIO RIVER—DRAINAGE.

For convenience, the following classified table, from General Humphreys' report upon "The Physics and Hydraulics of the Mississippi," is here introduced. There are many references to the Ohio River in that report which will prove valuable in the study of the hydraulics of this region.

Ohio River division.	Downfall of rain in inches.				
	Spring.	Summer.	Autumn.	Winter.	Year.
Huntsville	14.6	14.2	11.7	13.8	54.2
Nashville					
New Harmony					
Springdale					
Germantown	11.6	12.8	9.0	11.0	44.5
Cincinnati					
Newport					
Battle Creek					
Ann Arbor	7.8	10.5	7.2	4.9	30.8
Detroit					
Portsmouth					
Marietta					
Steubenville	9.2	10.5	9.3	7.7	36.5
Hudson					
Pittsburg					
Buffalo					
Fort Niagara	10.8	12.0	9.3	9.3	41.5
Mean					

The same report gives for the basin of the Ohio River 214,000 square miles; annual downfall of rain, 20,700,000,000,000 cubic feet, 5,000,000,000,000 cubic feet of which is discharged by the river, as shown by calculations, at Cairo. The ratio of discharge to downfall being 0.24.

Table exhibiting the observed and calculated discharge of the Alleghany and Monongahela. From these observations the table of average flowage of the Ohio River at Pittsburg was calculated.

Date.	Number of observations.	Rivers.	Depth shown by river marsh.	Average rate of current, feet per minute.	Discharge cubic feet per minute.	Total discharge of Ohio River, cubic feet per minute.	Average discharge calculated for channel enlargement shown by Monongahela pier marks.	Remarks.
May 2, 1868	1	Alleghany	7 0	108.00	1,280,950	.....	.....	River rising.
May 2, 1868	1	Monongahela	6 4	156.00	1,252,350	2,533,300	2,917,000	Strong wind down stream, river falling.
May 13, 1868	2	Alleghany	7 6	229.00	1,906,425	.....	.....	Wind up stream, river falling slowly.
May 13, 1868	2	Monongahela	6 4	137.20	1,101,460	3,007,885	2,917,000	Wind down, river falling.
May 22, 1868	3	Alleghany	7 7	202.20	1,701,978	.....	.....	River falling.
May 22, 1868	3	Monongahela	6 6	124.80	1,023,360	2,724,438	3,012,840	River falling slowly.
May 12, 1868	4	Alleghany	8 1	277.00	1,710,752	.....	.....	River falling.
May 12, 1868	4	Monongahela	7 1	166.00	1,476,275	3,187,027	3,357,100	River falling slowly.
Mar. 24, 1868	5	Alleghany	8 9	300.60	2,849,115	.....	.....	River falling.
Mar. 24, 1868	5	Monongahela	7 3	46.00	417,046	3,266,168	3,457,980	River falling slowly.
May 20, 1868	6	Alleghany	8 11	288.00	2,775,000	.....	.....	River falling.
May 20, 1868	6	Monongahela	8 0	156.00	1,460,625	4,235,625	3,925,800	River rising rapidly.
May 11, 1868	7	Alleghany	9 3	236.80	2,612,218	.....	.....	River falling.
May 11, 1868	7	Monongahela	8 7	187.50	1,932,723	4,544,941	4,305,340	River rising rapidly.
May 14, 1868	8	Alleghany	10 0	343.00	3,549,600	.....	.....	River falling.
May 14, 1868	8	Monongahela	8 7	124.00	1,272,059	4,821,659	4,305,340	River falling.
May 19, 1868	9	Alleghany	9 3	268.20	2,664,925	.....	.....	River falling.
May 19, 1868	9	Monongahela	8 7	176.40	1,823,167	4,488,092	4,753,900	River rising slowly.
Mar. 22, 1868	10	Alleghany	10 9	305.00	4,504,025	.....	.....	
Mar. 22, 1868	10	Monongahela	9 3	55.60	611,540	5,115,565	4,753,900	
May 15, 1868	11	Alleghany	10 6	321.00	3,563,100	.....	.....	
May 15, 1868	11	Monongahela	9 6	176.40	1,984,400	5,542,500	4,929,480	

Table exhibiting the observed and calculated discharge of the Alleghany and Monongahela rivers, &c.—Continued.

Date.	Number of observations.	Rivers.	Depth shown by river marsh.	Average rate of current, feet per minute.	Discharge cubic feet per minute.	Total discharge of Ohio River, cubic feet per minute.	Average discharge calculated for channel, depth shown by Monongahela pier marks.	Remarks.
May 7, 1868	12	Alleghany	<i>Pt. Ia.</i>	138.00	1,606,262	.....	.....	River falling.
May 7, 1868	12	Monongahela	11 1	330.00	4,481,810	.....	.....	River at a stand.
May 9, 1868	13	Alleghany	13 0	252.00	3,379,950	.....	6,605,100	River falling, high wind up.
May 9, 1868	13	Monongahela	12 6	260.40	3,758,982	.....	.....	River falling, high wind up.
Mar. 26, 1868	14	Alleghany	13 9	186.60	2,574,383	.....	6,803,880	River falling, high wind up.
Mar. 26, 1868	14	Monongahela	14 1	385.00	6,140,573	.....	.....	River falling, high wind up.
Mar. 20, 1868	15	Alleghany	15 0	486.00	7,417,575	.....	8,557,380	River falling rapidly.
Mar. 20, 1868	15	Monongahela	14 3	64.60	1,041,223	.....	.....	River at a stand.
Mar. 17, 1868	16	Alleghany	18 0	600.00	10,822,500	.....	8,705,300	River falling rapidly.
Mar. 17, 1868	16	Monongahela	17 6	80.75	1,572,606	.....	11,813,600	River at a stand.
Mar. 19, 1868	17	Alleghany	22 0	666.00	14,477,175	.....	.....	River at a stand.
Mar. 19, 1868	17	Monongahela	22 0	105.00	3,900,000	.....	16,882,480	

The points taken for observing the flowage of the two rivers at Pittsburg was for the Alleghany, between the Hand or Ninth-street bridge, and the St. Clair or Sixth-street suspension bridge, where the average width of the river is about 925 feet, with a smooth, regular bottom, three feet deep at low water. The Monongahela was measured between the Smithfield-street bridge and Wood street, where the average width is about 1,050 feet.

These places are both below bridge piers, which may have, in the higher stages, some influence upon the current, but they are the only convenient points about the city. The nearest point where the undivided river can well be gauged is below McKee's rocks, four miles down. It will be observed that the floods were sometimes out of one river and sometimes out of another, yet the general result was not sensibly effected thereby. The wind had considerable effect on the floats. The current was taken each time at three different points across the stream, with surface six feet, and at twelve feet depth at each, according to circumstances, all of which observations were averaged first separately, and then together.

During the low water of the summer of 1867, I gauged the flow passing down the two chutes of Brunot's Island, two and a half miles below the city, and found the amount to be about 108,000 cubic feet, when the marks at Pittsburg indicated zero.

There is fully a depth of over one foot in the narrow low-water channel, when the metal marks at Pittsburg shows six inches below zero, but navigation at that time is practically suspended.

Our tables, therefore, represent 100,000 cubic feet of water passing per minute, whenever the marks reach zero. It was necessary to make the table in this way from the zero marks, so as to have the tables correspond with the flowage at greater depths, as shown by the pier marks. More specific information in connection with these measurements is given in a special report on file in the office, dated May 22, 1868.

The following table exhibits the calculated minute, hourly, and daily flow of the Ohio River at Pittsburg, from zero up to twenty-two feet, flowage corresponding in depth shown by Monongahela pier marks:

Stage of water.	Flowage per minute.	Flowage per hour.	Flowage per day.	Stage of water.	Flowage per minute.	Flowage per hour.	Flowage per day.
<i>Ft. in.</i>	<i>Cubic feet.</i>	<i>Cubic feet.</i>	<i>Cubic feet.</i>	<i>Ft. in.</i>	<i>Cubic feet.</i>	<i>Cubic feet.</i>	<i>Cubic feet.</i>
0 0	100,000	6,000,000	144,000,000	3 6	6,215,100	372,906,000	8,949,744,000
0 3	180,340	10,820,400	259,698,600	6 6	6,408,840	384,530,400	9,228,729,600
0 6	263,200	15,792,000	379,008,000	9 6	6,605,100	396,306,000	9,511,344,000
0 9	348,560	20,914,800	501,955,200	12 0	6,803,880	408,232,800	9,797,587,200
1 0	436,480	26,188,800	628,531,200	3 3	7,005,180	420,310,800	10,087,459,200
1 3	526,900	31,614,000	755,736,000	6 7	7,209,000	432,540,000	10,380,960,000
1 6	619,840	37,190,400	892,569,600	9 9	7,415,340	444,920,400	10,678,089,600
1 9	715,300	42,918,000	1,030,032,000	13 0	7,623,200	457,392,000	10,977,408,000
2 0	813,280	48,796,800	1,171,123,200	3 3	7,834,580	470,074,800	11,281,795,200
2 3	913,780	54,836,800	1,315,843,200	6 8	8,048,480	482,908,800	11,589,811,200
2 6	1,016,800	61,008,000	1,464,192,000	9 9	8,264,900	495,894,000	11,901,456,000
2 9	1,123,340	67,340,400	1,616,169,600	14 0	8,483,840	509,030,400	12,216,729,600
3 0	1,234,400	74,064,000	1,777,536,000	3 3	8,705,300	522,318,000	12,535,632,000
3 3	1,344,980	80,688,800	1,936,771,200	6 8	8,929,280	535,756,800	12,858,163,200
3 6	1,458,080	87,484,800	2,099,635,200	9 9	9,155,780	549,346,800	13,184,323,200
3 9	1,573,700	94,422,000	2,266,128,000	15 0	9,384,800	561,088,000	13,466,110,000
4 0	1,691,840	101,510,400	2,436,249,600	3 3	9,616,340	576,980,400	13,847,529,600
4 3	1,812,500	108,750,000	2,610,000,000	6 8	9,850,400	591,024,000	14,184,576,000
4 6	1,935,680	116,140,800	2,787,379,200	9 9	10,086,980	605,218,800	14,525,251,200
4 9	2,061,380	123,682,800	2,968,387,200	16 0	10,326,080	619,564,800	14,869,555,200
5 0	2,189,600	131,376,000	3,153,024,000	3 3	10,567,700	634,062,000	15,217,488,000
5 3	2,320,340	139,220,400	3,341,289,600	6 8	10,811,840	648,710,400	15,569,049,600
5 6	2,453,600	147,216,000	3,533,184,000	9 9	11,058,500	663,510,000	15,924,240,000
5 9	2,590,380	155,422,800	3,730,147,200	17 0	11,307,680	678,460,800	16,283,059,200
6 0	2,728,680	163,720,800	3,929,299,200	3 3	11,559,380	693,562,800	16,645,507,200
6 3	2,869,500	172,170,000	4,132,180,000	6 8	11,813,600	708,816,000	17,011,584,000
6 6	3,012,840	180,770,400	4,388,489,600	9 9	12,070,340	724,220,400	17,381,289,600
6 9	3,158,840	189,522,000	4,548,528,000	18 0	12,329,600	739,776,000	17,754,624,000
7 0	3,307,080	198,424,800	4,762,195,200	3 3	12,591,380	755,482,800	18,131,587,200
7 3	3,457,980	207,478,800	4,979,491,200	6 8	12,855,680	771,340,800	18,512,179,200
7 6	3,611,400	216,684,000	5,200,416,000	9 9	13,122,500	787,350,000	18,896,400,000
7 9	3,767,340	226,040,400	5,424,969,600	19 0	13,398,400	803,510,400	19,284,249,600
8 0	3,925,800	235,548,000	5,653,152,000	3 3	13,673,700	820,422,000	19,690,068,000
8 3	4,086,780	245,206,800	5,884,963,200	6 8	13,948,080	836,884,800	20,095,235,200
8 6	4,250,280	255,016,800	6,120,403,200	9 9	14,224,980	853,498,800	20,483,971,200
8 9	4,416,300	264,978,000	6,359,472,000	20 0	14,504,000	870,264,000	20,886,336,000
9 0	4,584,840	275,090,400	6,602,169,600	3 3	14,786,340	887,180,400	21,392,329,600
9 3	4,755,900	275,354,000	6,608,496,000	6 8	15,070,800	904,248,000	21,701,952,000
9 6	4,929,480	295,768,800	7,098,451,200	9 9	15,357,780	921,466,800	22,115,203,200
9 9	5,105,580	306,334,800	7,352,035,000	21 0	15,647,280	938,836,800	22,532,083,200
10 0	5,284,200	317,052,000	7,409,248,000	3 3	15,939,300	956,358,000	22,952,592,000
10 3	5,465,340	327,920,400	7,870,089,600	6 8	16,231,840	973,910,400	23,373,849,600
10 6	5,649,000	338,940,000	8,134,560,000	9 9	16,525,900	991,554,000	23,797,296,000
10 9	5,835,180	350,110,800	8,420,650,200	22 0	16,822,480	1,009,348,800	24,224,371,200
11 0	6,023,880	361,432,800	8,674,387,200				

The following table exhibits the flowage at corresponding stages past Wheeling, (according to Ellet's calculations,) and at Pittsburg. Zero mark at Pittsburg, representing one foot in the ordinary low-water channel. One foot depth at Pittsburg, therefore, corresponds with a two-feet stage at Wheeling, two feet with three, &c. :

	Discharge in 24 hours, cubic feet.			Discharge in 24 hours, cubic feet.	
	Wheeling.	Pittsburg.		Wheeling.	Pittsburg.
1	102, 000, 000	144, 000, 000	12	3, 726, 000, 000	8, 674, 387, 200
2	228, 000, 000	628, 531, 200	13	4, 279, 000, 000	9, 797, 587, 200
3	400, 000, 000	1, 171, 123, 200	14	4, 854, 000, 000	10, 977, 408, 000
4	620, 000, 000	1, 777, 536, 000	15	5, 840, 000, 000	12, 216, 729, 600
5	864, 000, 000	2, 436, 249, 600	16	6, 103, 000, 000	13, 466, 110, 000
6	1, 164, 000, 000	3, 153, 024, 000	17	6, 744, 000, 000	14, 869, 555, 200
7	1, 511, 000, 000	3, 929, 299, 200	18	7, 413, 000, 000	17, 754, 624, 000
8	1, 890, 000, 000	4, 762, 195, 200	19	8, 100, 000, 000	19, 284, 249, 600
9	2, 314, 000, 000	5, 653, 152, 000	20	8, 819, 000, 000	20, 886, 336, 000
10	2, 754, 000, 000	6, 602, 169, 600	21	9, 556, 000, 000	22, 532, 083, 200
11	3, 225, 000, 000	7, 409, 248, 000			

The Alleghany River maintains its average fall of about $2\frac{1}{2}$ feet per mile, from Franklin, Pennsylvania, to its entrance into the Ohio, while the Ohio itself, for 25 miles below Pittsburg, has fully a third more fall than it has at Wheeling. The extra declivity or greater fall of the river, at Pittsburg, has thus a material effect in making the discharge greater at like stages there than at Wheeling. According to the above table a rise of 10 feet at Pittsburg, if not further swollen by the intervening tributaries, would furnish over 15 feet on the bar at Wheeling. This fact will account for a great part of the difference in discharge, at like stages, the two tables exhibit. Ellet may possibly have underestimated the discharge, and our tables may err somewhat in the opposite extreme, if indeed there be errors.

We have not in our possession any tables of late years for the daily depths shown by the Wheeling marks, with which to make comparisons. It is usual, however, I may say, to find, after a long continued rise at Pittsburg, a considerable greater depth in the channel at Wheeling, and increasing further in depth lower down on the river, even when the rise has been altogether from Pittsburg or with no appreciable addition to its volume from either the Big Beaver, Little Beaver, or other principal tributaries between Pittsburg and Wheeling. The river having much the same width from Pittsburg to Cincinnati, it is reasonable to presume that long continued floods from the Upper Ohio will increase in height in the exact ratio of velocity of the current, due to the diminished fall of the river as it descends.

Owing to the much greater width of the river between Cincinnati and Louisville, there being an increase of from 1,100 feet at Cincinnati to a mile in width at the head of the falls, the height of floods is thus greatly lessened at Louisville, notwithstanding the diminished fall below Cincinnati. A rise of 41 feet at Cincinnati, in September, 1866, made but 13 feet of a rise at Louisville, though immediately below, the river being contracted in width, the height of 41 feet was again exhibited.

In the case of a sudden flood of short duration the quantity of water required to fill up the channels, sluices, creeks, &c., will more than offset this peculiar damming. In such cases, therefore, a rise of ten feet at Pittsburg might not make ten feet in the river at Wheeling. Formerly the coal was floated down from Pittsburg in arks or barges drawing as much as seven feet; instances of their floating "ahead of the rise" and grounding were not uncommon, but very seldom did it happen that they were not able eventually to float off with the same rise.

Questions of practical utility in connection with this interesting subject will doubtless arise hereafter in considering the effect of dams, or other radical improvements which may be contemplated for this river.

Table exhibiting daily depths of water and calculated discharge of the Ohio River at Pittsburg during 1868 and 1869.

Day of month.	January, 1868.		January, 1869.	
	Depth.	Discharge.	Depth.	Discharge.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
1	7 0	4,762,195,200	10 4	7,975,843,200
2	6 4	4,200,480,000	14 8	12,057,200,000
3	6 1	4,021,780,800	13 6	11,589,811,200
4	7 10	5,528,937,200	11 7	9,322,531,200
5	7 2	4,906,656,000	11 3	8,949,744,000
6	6 11	4,690,569,600	12 9	10,678,089,600
7	6 4	4,200,480,000	10 5	8,046,000,000
8	8 6	6,121,403,200	9 3	6,848,496,000
9	11 0	8,674,387,200	8 4	5,963,040,000
10	8 9	6,359,472,000	10 0	7,409,248,000
11	6 1	3,996,489,600	12 7	10,479,600,000
12	5 2	3,278,131,200	16 0	14,869,555,200
13	4 0	2,436,249,600	14 4	12,642,739,200
14	3 4	1,990,656,000	10 9	8,402,659,200
15	2 11	1,719,504,000	9 1	6,683,857,200
16	3 8	2,210,227,200	8 10	6,439,968,000
17	3 5	2,044,944,000	10 2	7,782,739,200
18	3 3	1,936,771,400	9 0	6,602,169,000
19	3 1	1,830,221,200	7 6	5,200,416,000
20	2 11	1,171,123,200	6 10	4,619,347,200
21	3 0	1,777,536,000	6 1	3,996,489,600
22	3 9	2,266,128,000	5 6	3,533,184,000
23	4 2	2,551,680,000	5 3	3,341,289,600
24	6 0	3,929,299,200	5 3	3,341,289,600
25	7 11	5,576,688,000	5 0	3,153,024,000
26	6 7	4,408,099,200	4 8	2,907,648,000
27	5 6	3,599,395,200	4 2	2,551,680,000
28	5 1	3,215,376,000	3 11	2,379,139,200
29	5 3	3,341,289,600	3 10	2,322,432,000
30	3 9	2,266,128,000	4 9	2,968,387,200
31	3 7	2,154,729,600	7 0	4,762,195,200
	5 4+	111,166,017,800	5 7+	207,818,811,800

Day of month.	February, 1868.		February, 1869.	
	Depth.	Discharge.	Depth.	Discharge.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
1	3 4	1,990,656,000	6 9	4,548,528,000
2	3 1	1,830,221,200	5 0	3,153,024,000
3	2 10	1,667,635,200	5 7	3,599,395,200
4	2 7	1,514,448,000	5 0	3,153,024,000
5	2 4	1,364,889,600	6 5	4,269,283,200
6	2 1	1,218,960,000	6 5	4,269,283,200
7	2 6	1,464,192,000	6 1	3,996,489,600
8	2 4	1,364,889,600	5 7	3,599,395,200
9	2 3	1,315,843,200	6 3	4,132,080,000
10	3 10	2,322,432,000	8 3	5,884,963,200
11	7 1	4,834,224,000	9 9	7,352,035,000
12	8 9	6,359,472,000	9 2	6,765,984,000
13	6 8	4,478,112,000	8 10	6,439,968,000
14	5 5	3,468,816,000	9 1	6,683,857,200
15	4 11	3,091,075,000	10 2	7,782,739,200
16	4 7	2,847,312,000	14 3	12,535,632,000
17	4 4	2,668,723,200	13 0	10,977,408,000
18	4 6	2,787,379,200	11 1	9,710,769,600
19	4 4	2,668,723,200	9 9	7,352,035,200
20	4 4	2,668,723,200	8 6	6,120,403,200
21	5 3	3,341,289,600	7 11	5,576,688,000
22	6 7	4,408,099,200	7 10	5,500,627,200
23	6 7	4,408,099,200	8 7	6,199,689,600
24	6 2	4,064,083,200	9 6	7,098,451,200
25	7 1	4,834,224,000	8 4	5,963,040,000
26	7 0	4,762,195,200	7 4	5,052,729,600
27	6 4	4,200,480,000	6 9	4,548,528,000
28	6 11	4,690,569,600	6 2	4,064,083,200
29	5 10	3,796,128,000		
	4 9+	90,431,884,600	8 1+	166,321,133,800

Table exhibiting daily depths of water of the Ohio River, 1868 and 1869, &c.—Continued.

Day and month.	March, 1868.			March, 1869.		
	Depth.		Discharge.	Depth.		Discharge.
	<i>Ft.</i>	<i>In.</i>		<i>Ft.</i>	<i>In.</i>	
1.....	5	3	3,341, 259, 600	5	3	3,341, 259, 600
2.....	5	2	3,278, 131, 200	4	7	2,847, 312, 000
3.....	6	8	4,478, 112, 000	4	10	3,029, 529, 600
4.....	6	10	4,619, 347, 200	5	0	3,153, 024, 000
5.....	6	2	4,064, 083, 200	3	5	2,727, 849, 600
6.....	5	0	3,153, 024, 000	4	0	2,436, 249, 600
7.....	6	2	4,064, 083, 200	3	2	1,883, 289, 600
8.....	10	7	8,223, 523, 200	2	11	1,719, 504, 000
9.....	15	6	14,184, 576, 000	3	4	1,990, 656, 000
10.....	15	7	14,297, 731, 200	4	5	2,727, 849, 600
11.....	16	4	15,334, 282, 000	10	9	8,402, 659, 200
12.....	16	8	15,805, 440, 000	12	5	10,282, 723, 200
13.....	16	1	14,985, 129, 600	10	0	7,409, 284, 000
14.....	17	4	16,767, 129, 600	8	9	6,359, 472, 000
15.....	16	4	15,334, 272, 000	8	0	5,653, 152, 000
16.....	16	6	15,569, 049, 600	7	9	5,424, 969, 600
17.....	21	5	23,233, 507, 200	7	6	5,200, 416, 000
18.....	19	11	20,751, 811, 200	7	1	4,384, 224, 000
19.....	17	0	16,283, 059, 200	6	3	4,132, 080, 000
20.....	14	4	12,264, 739, 200	6	1	3,996, 489, 600
21.....	14	8	9,416, 736, 000	6	4	4,200, 480, 000
22.....	9	7	7,182, 576, 000	6	9	4,548, 528, 000
23.....	7	11	5,576, 688, 000	6	6	4,338, 489, 600
24.....	7	3	4,979, 491, 200	6	3	4,132, 080, 000
25.....	8	10	6,439, 968, 000	6	1	3,996, 489, 600
26.....	14	3	12,535, 632, 000	7	2	4,906, 656, 000
27.....	15	6	14,184, 576, 000	14	9	13,184, 323, 200
28.....	13	1	11,078, 467, 200	15	3	13,847, 529, 600
29.....	9	10	7,437, 369, 600	14	6	12,858, 163, 200
30.....	8	6	6,120, 403, 200	16	6	15,569, 049, 600
31.....	7	6	5,200, 416, 000	19	9	20,483, 971, 200
	11	10+	324, 562, 633, 600	7	11+	189, 617, 747, 200

Day of month.	April, 1868.			April, 1869.		
	Depth.		Discharge.	Depth.		Discharge.
	<i>Ft.</i>	<i>In.</i>		<i>Ft.</i>	<i>In.</i>	
1.....	6	8	4,478, 112, 000	17	2	16,524, 288, 000
2.....	6	5	4,269, 283, 200	14	9	13,184, 323, 000
3.....	6	1	3,996, 489, 600	13	9	11,901, 456, 000
4.....	6	2	4,064, 038, 200	12	3	10,087, 459, 200
5.....	5	9	3,730, 147, 200	10	2	7,782, 739, 200
6.....	5	6	3,533, 184, 000	8	9	6,359, 472, 000
7.....	7	3	4,979, 491, 200	8	0	5,653, 152, 000
8.....	7	6	5,200, 416, 000	7	8	5,349, 715, 200
9.....	6	7	4,408, 099, 200	7	4	5,052, 729, 600
10.....	6	0	3,929, 299, 200	6	10	4,619, 347, 200
11.....	7	5	5,126, 371, 200	7	0	4,762, 195, 200
12.....	8	5	6,041, 520, 000	6	9	4,548, 528, 000
13.....	10	5	4,046, 000, 000	6	10	4,619, 347, 200
14.....	12	0	9,797, 587, 200	7	0	4,762, 195, 200
15.....	11	2	8,857, 555, 200	6	8	4,478, 112, 000
16.....	10	10	8,492, 832, 000	6	4	4,200, 480, 000
17.....	11	5	9,135, 331, 200	6	1	3,996, 489, 600
18.....	10	2	7,782, 739, 200	6	4	4,200, 480, 000
19.....	8	10	6,493, 968, 000	8	0	5,653, 152, 000
20.....	7	6	5,200, 416, 000	8	9	6,359, 472, 000
21.....	6	11	4,690, 569, 600	9	0	6,602, 169, 600
22.....	6	9	4,548, 528, 000	10	2	7,782, 739, 200
23.....	6	6	4,338, 489, 600	9	7	7,182, 576, 000
24.....	5	5	3,468, 816, 000	8	1	5,730, 019, 200
25.....	5	0	3,153, 024, 000	7	5	5,126, 371, 200
26.....	5	0	3,153, 024, 000	6	8	4,478, 112, 000
27.....	5	0	3,153, 024, 000	6	0	3,929, 299, 200
28.....	4	11	3,091, 075, 200	5	2	3,278, 131, 200
29.....	4	9	2,968, 387, 200	4	11	3,091, 075, 200
30.....	5	1	3,215, 376, 000	5	2	3,278, 131, 200
	7	3	53, 289, 238, 400	8	4+	184, 573, 756, 800

Table exhibiting daily depths of water of the Ohio River, 1868 and 1869, &c.—Continued.

Day of month.	May, 1868.		May, 1869.	
	Depth.	Discharge.	Depth.	Discharge.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
1.	6 0	3,929,299,200	8 2	5,807,289,600
2.	6 7	4,408,099,200	9 4	6,931,411,200
3.	7 2	2,906,656,000	12 0	9,797,587,200
4.	7 8	5,349,715,200	11 5	9,135,331,200
5.	8 1	5,730,019,200	9 0	6,602,169,600
6.	7 7	5,274,864,000	7 7	5,274,864,000
7.	12 1	9,893,808,000	7 2	4,906,656,000
8.	12 2	9,990,432,000	7 4	5,052,729,600
9.	12 6	10,380,960,000	7 1	4,834,224,000
10.	9 9	7,352,035,200	6 10	4,619,347,200
11.	8 4	5,963,040,000	6 2	4,064,083,200
12.	7 4	5,052,729,600	5 1	3,215,376,000
13.	6 9	4,548,528,000	4 8	2,907,648,000
14.	7 10	5,500,627,200	4 8	2,907,648,000
15.	9 8	7,267,104,000	5 1	3,215,376,000
16.	11 0	8,674,387,200	6 0	3,929,299,200
17.	10 5	8,046,000,000	6 6	4,338,489,600
18.	9 8	7,267,104,000	6 2	4,064,083,200
19.	8 6	6,120,403,200	5 2	3,278,131,200
20.	7 10	5,500,627,200	5 0	3,153,024,000
21.	7 1	4,834,224,000	4 11	3,091,075,200
22.	6 7	4,408,099,200	5 4	3,404,851,200
23.	6 1	3,996,489,600	6 6	4,338,489,600
24.	5 5	3,468,816,000	6 0	3,929,299,200
25.	5 0	3,153,024,000	5 7	3,599,395,200
26.	4 0	2,436,249,600	5 0	3,153,024,000
27.	4 9	2,968,387,200	4 11	3,091,075,200
28.	5 6	3,533,184,000	5 7	3,599,395,200
29.	8 5	6,041,520,000	5 10	3,796,128,000
30.	10 10	8,492,832,000	6 3	4,132,080,000
31.	11 1	8,765,769,600	7 5	3,126,371,200
	4 10+	183,255,033,600	6 7+	139,295,952,000

Day of month.	June, 1868.		June, 1869.	
	Depth.	Discharge.	Depth.	Discharge.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
1.	9 4	6,931,411,200	8 0	5,653,152,000
2.	7 5	5,126,371,200	7 10	5,500,627,200
3.	6 3	4,132,080,000	7 1	4,834,224,000
4.	6 0	3,929,299,200	6 4	4,200,480,000
5.	5 3	3,341,289,600	6 0	3,929,299,200
6.	4 5	2,727,849,600	6 8	4,478,112,000
7.	6 10	4,619,347,200	7 3	4,979,469,200
8.	8 4	5,963,040,000	6 9	4,548,528,000
9.	7 8	5,349,715,200	5 11	3,862,512,000
10.	6 7	4,408,099,200	5 1	3,215,376,000
11.	5 10	3,796,128,000	4 11	3,091,075,200
12.	5 2	3,278,131,200	4 6	2,787,379,200
13.	4 5	2,727,849,600	4 6	2,787,379,200
14.	4 1	2,493,763,200	4 9	2,968,387,200
15.	3 9	2,266,128,000	5 6	3,533,184,000
16.	3 4	1,990,656,000	5 5	3,468,816,000
17.	3 0	1,777,536,000	4 10	3,029,529,600
18.	2 11	1,719,504,000	4 3	2,610,000,000
19.	2 9	1,616,169,600	3 8	2,210,227,200
20.	2 6	1,464,192,000	3 6	2,099,635,200
21.	2 8	1,565,107,200	4 8	2,907,648,000
22.	3 0	1,777,536,000	8 2	5,807,289,600
23.	4 4	2,668,723,200	7 10	5,500,627,200
24.	3 9	2,266,128,000	7 4	5,052,729,600
25.	3 2	1,883,289,600	5 11	3,862,512,000
26.	2 7	1,514,448,000	5 5	3,468,816,000
27.	3 0	1,777,536,000	5 8	3,664,569,600
28.	2 6	1,464,192,000	5 10	3,796,128,000
29.	2 3	1,315,843,200	6 0	3,929,299,200
30.	1 10	1,076,659,200	9 0	6,602,169,600
	4 6	86,968,022,200	5 11+	118,379,203,200

Table exhibiting daily depths of water of the Ohio River, 1868 and 1869, &c.—Continued.

Day of month.	July, 1868.			July, 1869.		
	Depth.		Discharge.	Depth.		Discharge.
	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>
1.....	1	7	937, 987, 200	11	6	9, 228, 729, 600
2.....	1	5	847, 555, 200	10	4	7, 957, 843, 200
3.....	1	4	802, 944, 000	8	10	6, 439, 968, 000
4.....	1	3	758, 736, 000	8	10	6, 439, 968, 000
5.....	1	3	758, 736, 000	8	10	6, 439, 968, 000
6.....	1	3	758, 736, 000	7	11	5, 576, 688, 000
7.....	1	4	802, 944, 000	6	6	4, 338, 489, 600
8.....	2	3	1, 315, 843, 200	5	6	3, 533, 184, 000
9.....	2	1	1, 218, 960, 000	6	0	3, 929, 299, 200
10.....	1	8	983, 808, 000	8	10	6, 439, 968, 000
11.....	1	4	802, 944, 000	8	2	5, 807, 289, 600
12.....	1	9	1, 030, 032, 000	7	0	4, 762, 195, 200
13.....	1	7	937, 987, 200	6	4	4, 200, 480, 000
14.....	1	5	847, 555, 200	5	5	3, 468, 816, 000
15.....	1	3	758, 736, 000	5	8	3, 664, 569, 600
16.....	0	11	585, 936, 000	6	8	4, 473, 112, 000
17.....	0	8	460, 569, 600	8	10	6, 439, 968, 000
18.....	0	5	338, 832, 000	9	8	7, 267, 194, 000
19.....	0	7	419, 587, 200	10	8	8, 312, 889, 000
20.....	1	0	628, 531, 200	13	3	11, 281, 795, 200
21.....	0	11	585, 936, 000	11	0	8, 674, 387, 200
22.....	0	7	419, 587, 200	8	0	5, 653, 152, 000
23.....	1	2	714, 931, 200	6	5	4, 269, 283, 200
24.....	1	5	847, 555, 200	5	10	3, 796, 128, 000
25.....	1	8	983, 808, 000	5	8	3, 664, 569, 600
26.....	1	6	890, 569, 600	5	2	3, 278, 131, 200
27.....	1	9	1, 030, 032, 000	5	0	3, 153, 024, 000
28.....	1	7	937, 987, 200	4	11	3, 091, 075, 200
29.....	1	6	892, 569, 600	5	4	3, 404, 851, 200
30.....	2	0	1, 171, 123, 200	5	6	3, 533, 184, 000
31.....	1	10	1, 076, 659, 200	6	1	3, 996, 489, 600
	1	4	25, 549, 718, 400	7	6+	166, 521, 600, 000

Day of month.	August, 1868.			August, 1869.		
	Depth.		Discharge.	Depth.		Discharge.
	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>
1.....	1	7	937, 987, 200	5	2	3, 278, 131, 200
2.....	1	6	892, 569, 600	4	5	2, 727, 849, 600
3.....	8	1	5, 730, 019, 200	3	11	2, 379, 139, 200
4.....	7	7	5, 274, 864, 000	3	5	2, 044, 944, 000
5.....	5	0	3, 153, 024, 000	3	5	2, 044, 944, 000
6.....	3	11	2, 379, 139, 200	3	6	2, 099, 635, 200
7.....	3	7	2, 154, 729, 600	3	8	2, 210, 227, 200
8.....	2	5	1, 404, 339, 200	3	5	2, 044, 944, 000
9.....	2	0	1, 171, 123, 200	2	9	1, 616, 169, 600
10.....	2	0	1, 171, 123, 200	2	5	1, 414, 339, 200
11.....	1	8	983, 808, 000	2	1	1, 218, 960, 000
12.....	1	6	892, 569, 600	2	0	1, 171, 123, 200
13.....	1	3	758, 736, 000	1	11	1, 123, 689, 600
14.....	0	7	419, 587, 200	1	10	1, 076, 659, 200
15.....	0	4	299, 059, 200	1	10	1, 076, 659, 200
16.....	0	2	220, 723, 200	1	10	1, 076, 659, 200
17.....	0	0	144, 000, 000	1	11	1, 123, 689, 600
18.....	0	0	144, 000, 000	1	10	1, 076, 659, 200
19.....	0	0	144, 000, 000	1	8	983, 808, 000
20.....	0	0	144, 000, 000	1	7	937, 987, 200
21.....	0	0	144, 000, 000	1	6	892, 569, 600
22.....	0	0	144, 000, 000	1	7	937, 987, 200
23.....	0	0	144, 000, 000	1	9	1, 030, 032, 000
24.....	0	0	144, 000, 000	2	3	1, 315, 843, 200
25.....	0	0	144, 000, 000	2	8	1, 563, 107, 200
26.....	0	0	144, 000, 000	2	5	1, 414, 339, 200
27.....	0	6	379, 008, 000	2	2	1, 267, 200, 000
28.....	0	1	182, 160, 000	2	0	1, 171, 123, 200
29.....	0	2	220, 723, 200	2	0	1, 171, 123, 200
30.....	0	4	299, 059, 200	2	1	1, 218, 960, 000
31.....	0	3	259, 689, 600	2	3	1, 315, 843, 200
	1	5	30, 634, 041, 600	2	6	46, 026, 345, 600

Table exhibiting daily depths of water of the Ohio River, 1868 and 1869, &c.—Continued.

Day of month.	September, 1868.			September, 1869.		
	Depth.		Discharge.	Depth.		Discharge.
	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>
1	0	4	299,059,200	2	5	1,414,339,200
2	0	6	379,008,000	2	3	1,315,843,200
3	0	11	585,936,000	1	9	1,030,032,000
4	3	1	1,830,211,200	1	9	1,030,032,000
5	3	8	2,210,227,200	1	3	758,736,000
6	2	11	1,719,504,000	1	1	671,529,600
7	3	1	1,830,211,200	1	4	758,736,000
8	3	0	1,777,536,000	2	9	1,616,169,600
9	3	2	1,883,289,600	12	6	10,380,960,000
10	3	10	2,322,432,000	13	3	11,281,795,200
11	6	2	4,064,032,200	6	8	7,257,104,000
12	7	1	4,834,224,000	8	9	6,359,472,000
13	7	5	5,126,371,200	6	7	4,408,099,200
14	8	0	5,653,152,000	5	8	3,664,569,600
15	8	9	6,359,472,000	5	0	3,153,224,000
16	8	3	5,884,963,200	4	4	2,668,723,200
17	6	3	4,132,080,000	3	9	2,226,128,000
18	5	3	3,341,289,600	3	3	1,936,771,200
19	4	3	2,610,000,000	2	9	1,619,169,600
20	3	10	2,322,432,000	2	6	1,464,192,000
21	3	4	1,990,656,000	2	3	1,315,843,300
22	6	8	4,478,112,000	2	1	1,218,960,000
23	10	3	7,870,089,600	2	0	1,171,123,200
24	11	6	9,228,729,600	2	0	1,171,123,200
25	15	1	13,624,848,000	1	10	1,076,659,200
26	18	8	18,767,923,200	2	6	1,464,192,000
27	13	4	11,384,064,000	6	1	3,996,489,600
28	10	0	7,409,248,000	7	1	4,834,224,000
29	7	5	5,126,371,200	6	3	4,132,080,000
30	5	11	3,862,512,000	5	4	3,404,851,200
	6	4+	142,908,035,200	4	2+	88,847,971,200

Day of month.	October, 1868.			October, 1869.		
	Depth.		Discharge.	Depth.		Discharge.
	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>	<i>Ft.</i>	<i>In.</i>	<i>Cubic feet.</i>
1	4	10	3,029,529,609	4	7	2,847,312,000
2	4	4	2,668,723,200	4	2	2,551,680,000
3	4	3	2,610,000,000	4	1	2,493,736,200
4	4	3	2,610,000,000	4	2	2,551,680,000
5	4	2	2,551,680,000	5	0	3,153,024,000
6	3	6	2,099,635,200	5	0	3,153,024,000
7	3	0	1,777,536,000	4	2	2,551,680,000
8	3	0	1,777,536,000	3	8	2,210,227,200
9	3	0	1,777,536,000	3	4	1,990,656,000
10	2	7	1,514,448,000	3	3	1,936,771,200
11	2	2	1,267,200,000	3	1	1,830,211,200
12	2	0	1,171,123,200	2	10	1,667,635,200
13	1	9	1,030,032,000	2	9	1,616,169,600
14	1	8	983,808,000	2	0	1,171,123,200
15	1	7	937,987,200	2	6	1,464,192,000
16	1	5	847,555,200	3	0	1,777,536,000
17	1	4	802,944,000	2	8	1,565,107,200
18	1	3	758,736,000	2	5	1,414,339,200
19	1	3	758,736,000	2	2	1,267,200,000
20	1	3	758,736,000	2	1	1,218,960,000
21	1	2	714,931,200	1	11	1,123,696,600
22	1	2	714,931,200	1	11	1,123,696,600
23	1	4	802,944,000	2	0	1,171,123,200
24	1	2	714,931,200	2	3	1,315,843,200
25	1	5	847,555,200	2	6	1,464,192,000
26	1	8	983,808,000	4	2	2,551,680,000
27	1	8	983,808,000	4	0	2,436,249,600
28	1	7	937,987,200	3	7	2,154,729,600
29	1	6	892,569,600	3	2	1,883,289,600
30	1	5	847,555,200	3	0	1,777,536,000
31	1	4	802,944,000	2	10	1,667,635,200
	2	2+	40,977,446,400	5	10+	59,101,948,800

Table exhibiting daily depths of water of the Ohio River, 1868 and 1869, &c.—Continued.

Day of month.	November, 1868.		November, 1869.	
	Depth.	Discharge.	Depth.	Discharge.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
1.....	2 9	1,616, 169, 600	2 10	1,667, 635, 200
2.....	8 0	5,563, 152, 000	2 8	1,565, 107, 200
3.....	8 10	6,439, 968, 000	2 8	1,565, 107, 200
4.....	7 9	5,4299, 69, 600	2 4	1,364, 889, 600
5.....	6 4	4,200, 480, 000	2 3	1,315, 843, 200
6.....	5 5	3,468, 816, 000	2 1	1,218, 960, 000
7.....	5 1	3,215, 376, 000	2 1	1,218, 960, 000
8.....	5 0	3,153, 024, 000	2 1	1,218, 960, 000
9.....	4 10	3,029, 529, 600	2 1	1,218, 960, 000
10.....	4 7	2,847, 312, 000	2 1	1,218, 960, 000
11.....	7 6	5,200, 416, 000	2 2	1,267, 200, 000
12.....	8 6	6,120, 403, 200	2 1	1,218, 960, 000
13.....	8 2	5,807, 289, 600	2 0	1,171, 123, 200
14.....	7 4	5,052, 729, 600	2 0	1,171, 123, 200
15.....	6 4	4,200, 480, 000	2 0	1,171, 123, 200
16.....	5 5	3,468, 816, 000	2 0	1,171, 123, 200
17.....	5 4	3,404, 851, 200	2 0	1,171, 123, 200
18.....	5 6	3,533, 184, 000	2 0	1,171, 123, 200
19.....	7 4	5,052, 729, 600	2 9	1,616, 169, 600
20.....	7 6	5,200, 416, 000	2 6	2,099, 635, 200
21.....	7 2	4,906, 656, 000	3 7	2,154, 729, 600
22.....	6 5	4,269, 283, 200	3 6	2,099, 635, 200
23.....	5 9	3,730, 147, 200	3 5	2,044, 944, 000
24.....	5 6	3,533, 184, 000	3 5	2,044, 944, 000
25.....	5 4	3,404, 851, 200	3 9	2,266, 128, 000
26.....	5 5	3,468, 816, 000	4 3	2,610, 000, 000
27.....	11 6	9,222, 729, 600	4 5	2,727, 849, 600
28.....	12 0	9,797, 587, 200	5 2	3,278, 131, 200
29.....	9 10	7,437, 369, 600	6 1	3,996, 489, 600
30.....	8 2	5,807, 289, 600	5 11	3,862, 512, 000
	6 9+	141, 674, 625, 600	2 8	53, 887, 449, 600

Day of month.	December, 1868.		December, 1869.	
	Depth.	Discharge.	Depth.	Discharge.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
1.....	3 1	1,830, 211, 200	10 8	8,312, 889, 600
2.....	6 4	4,200, 480, 000	15 8	14,411, 289, 600
3.....	5 10	3,796, 128, 000	13 2	11,179, 929, 600
4.....	5 3	3,341, 289, 000	11 1	8,765, 769, 600
5.....	4 9	2,968, 387, 200	9 6	7,098, 451, 200
6.....	5 4	3,404, 851, 200	8 1	5,730, 019, 200
7.....	6 11	4,690, 569, 600	7 5	5,126, 371, 200
8.....	7 6	5,200, 516, 000	6 10	4,619, 347, 200
9.....	7 9	5,429, 696, 600	6 1	3,996, 489, 600
10.....	6 3	4,132, 080, 000	5 7	3,599, 395, 200
11.....	5 0	3,153, 024, 000	5 4	3,404, 851, 200
12.....	4 2	2,551, 680, 000	5 6	3,533, 184, 000
13.....	3 7	2,154, 729, 600	6 4	4,200, 480, 000
14.....	3 0	1,777, 536, 000	7 2	4,906, 656, 000
15.....	3 8	2,210, 227, 200	7 2	4,906, 656, 000
16.....	4 1	2,493, 763, 200	9 3	6,848, 496, 000
17.....	4 7	2,847, 312, 000	11 10	9,606, 355, 200
18.....	5 10	3,796, 128, 000	10 10	8,492, 822, 000
19.....	7 0	4,762, 195, 200	9 4	6,931, 411, 200
20.....	6 5	4,269, 238, 200	8 0	5,653, 152, 000
21.....	7 4	5,052, 729, 600	6 9	4,548, 528, 000
22.....	8 5	6,041, 520, 000	7 2	4,006, 656, 000
23.....	7 2	4,979, 491, 200	14 2	12,428, 928, 000
24.....	6 4	4,200, 480, 000	14 0	12,216, 729, 600
25.....	5 0	3,153, 024, 000	10 2	7,782, 739, 200
26.....	5 0	3,153, 024, 000	8 11	6,520, 867, 200
27.....	4 9	2,968, 387, 200	8 5	6,041, 520, 000
28.....	4 10	3,029, 529, 600	10 0	7,409, 248, 000
29.....	4 9	2,968, 387, 200	10 7	8,223, 523, 200
30.....	4 8	2,907, 648, 000	9 4	6,931, 411, 200
31.....	5 9	3,730, 147, 200	8 6	6,120, 403, 200
	5 2+	111, 189, 628, 800	9 1+	214, 454, 579, 200

Summary of discharge of the Ohio River at Pittsburg for 1868 and 1869.

Months.	Average depth.	1868.	Average depth.	1869.
	<i>Ft. In.</i>	<i>Cubic feet.</i>	<i>Ft. In.</i>	<i>Cubic feet.</i>
January	5 4	111, 166, 017, 200	5 7	207, 818, 881, 800
February	4 9	90, 431, 884, 600	8 1	166, 321, 133, 800
March	11 10	324, 562, 633, 600	7 11	189, 617, 747, 200
April	7 3	53, 289, 238, 400	8 4	184, 753, 756, 800
May	4 10	183, 255, 633, 600	6 7	139, 295, 952, 000
June	4 6	86, 968, 022, 400	5 11	118, 379, 203, 200
July	1 4	25, 549, 718, 400	7 6	166, 521, 600, 000
August	1 5	30, 634, 041, 600	2 6	46, 626, 345, 600
September	6 4	142, 908, 035, 200	4 2	88, 847, 971, 200
October	2 2	40, 977, 446, 400	5 10	59, 101, 948, 800
November	6 9	141, 674, 025, 600	2 8	53, 887, 449, 600
December	5 2	111, 189, 638, 800	9 1	214, 454, 579, 200
	5 1	1, 342, 605, 725, 800	6 2	1, 634, 846, 499, 200

Average daily discharge for 1868..... 36,783,444,542 cubic feet.
 Average daily discharge for 1869..... 44,790,309,000 cubic feet.

UNITED STATES ENGINEER'S OFFICE,
 OHIO RIVER IMPROVEMENT,
Pittsburg, Pennsylvania, January 15, 1870.

SIR: I have the honor to submit the following report upon the trade and commerce of the Ohio River, pursuant to your verbal instructions given in December, 1868.

Through the winter following, the time I commenced to collect statistics relative to this subject, I was delayed by the tardiness in the correspondence of those whom I addressed, and during all the summer season of 1869 I was so busily engaged in the superintendence of the works and surveys that I could find no time to devote to the subject; for these reasons I beg you to excuse the delay consequent in carrying out your instructions.

In order to reach in a general way the business of the prominent towns and landings, I had the following circular printed and forwarded to the wharf-boat masters, or other proper persons, at ninety points on the Ohio, in addition to numerous personal accompanying letters to the more prominent places.

"UNITED STATES ENGINEER'S OFFICE,
 "OHIO RIVER IMPROVEMENT,
"Pittsburg, Pennsylvania, December 11, 1868.

"SIR: By command of W. Milnor Roberts, United States civil engineer, &c., I am directed to collect such statistics of the business done at the several cities and prominent towns along the Ohio River and tributaries as will serve to show the importance of these rivers as national highways of commerce.

"The general statistics we believe will show how important it is that Congress should early grant more means, so that the rivers can be radically improved, while at the same time the report itself will be useful and interesting to the large class engaged in the business and navigation of the rivers.

"I would be much obliged if you could give me—

"First. The number of steamboats, barges, &c., built at your place during the last year, and in former years, with the tonnage of each class, value, &c.

"Second. The number of steamboat arrivals and departures during the past year, and former years, if possible.

"Third. Number of passengers, quantity of freight received and shipped, value, &c., and, in a general way, the kinds of freight.

"Fourth. Quantity of coal, iron, lumber, salt, &c., received and exported per annum, value, &c., and generally such information in regard to the commerce and navigation of the Ohio and its tributaries as may be in your power to give, and which will be important to mention in a report to the Department at Washington.

"Your kind attention to this will receive the thanks of Mr. Roberts; and any favor in his power to do in return will be promptly attended to.

"Very respectfully, yours,

"THOS. P. ROBERTS,
"Assistant United States Civil Engineer."

To this circular and letters, I regret to say, there were but seventeen answers, many of which speak in such general terms that no accurate idea can be obtained of the exact amount and value of the business done at each place. Still they are not without

interest and value, and as they are tolerably well distributed I present them below for further reference.

The points from which answers were received are as follows, viz:

	Miles below Pittsburgh.
No. 1, Freedom, Pa.	24 $\frac{1}{2}$
No. 2, East Liverpool, Ohio.	44
No. 3, Steubenville, Ohio.	67 $\frac{1}{2}$
No. 4, Bellair, Ohio.	93 $\frac{1}{2}$
No. 5, Matamoras, Ohio.	141 $\frac{1}{2}$
No. 6, Hockingport, Ohio.	197 $\frac{1}{2}$
No. 7, Concord, Kentucky.	387
No. 8, Maysville, Kentucky.	405 $\frac{1}{2}$
No. 9, Dover, Kentucky.	416 $\frac{1}{2}$
No. 10, Florence, Indiana.	489
No. 11, Aurora, Indiana.	482 $\frac{3}{4}$
No. 12, West Point, Kentucky.	575
No. 13, Jefferson, Indiana.	597 $\frac{1}{2}$
No. 14, Louisville, Kentucky.	598 $\frac{1}{2}$
No. 15, Tell City, Indiana.	720
No. 16, Rockport, Indiana.	740 $\frac{1}{2}$
No. 17, Evansville, Indiana.	783

Letters received.

No. 1.

FREEDOM, PA., December 29, 1868.

DEAR SIR: Below please find approximated statistics of Freedom, as per your request:

	Tonnage.	Cost.
1866. Steamboat hulls built:		
1 for Captain S. Fowler, Pittsburg.	152	\$6, 250
1 for Captain John Hare, Pittsburg.	308	7, 550
1867. Steamboat hulls built:		
1 for Captain N. Scovill, New Orleans.	139	4, 506
1 for Captain E. E. Merriman, New York.	150	3, 845
1 for Captain P. F. Guise, Wellsville.	75	2, 000
1867. Ferry boat:		
1 for Captain P. F. Guise, Wellsville.	172	6, 220
1868. Steamboat hulls built:		
1 for Captain P. F. Guise, Wellsville.	116	3, 340
1 for Captain P. F. Guise, Wellsville.	86	2, 275
1 for Captain John Woodburn, Pittsburg.	132	2, 759
1 for Captain T. S. Taylor, Wheeling.	87	2, 175
1 for Captain T. W. Rea, St. Louis.	370	8, 025
1868. Model barge:		
1 for Captain John V. McDonald, Pittsburg.	153	2, 000
1 for United States Government.	74	1, 300
1868. Coal barge:		
1 for McCaskey & Kerr, Freedom.	424	2, 600
Total.	2, 438	55, 145
To the above add 25 coal-flats for each year, and we have a total of 75 flats, carrying 60 tons each, at a cost, each, of \$500, making a total of..	4, 500	37, 500
And a grand total of tonnage and cost for three years, ending December 31, 1868, of.....	6, 938	92, 645

We receive annually about 40,000 bushels of coal. Hoping the foregoing will answer your questions satisfactorily,

We remain, &c.,

MCCASKEY & KERR.

We find by reference to the books of the railroad agent at this place that the passengers leaving here will approximate 2,000 annually; those arriving, about the same.

Freight received will amount to about 200,000 pounds annually; that shipped, to perhaps 400,000 pounds; bringing a revenue to the railroad company of, respectively, \$2,000 and \$4,000.

Lumber received will amount to 600,000 cubic feet; exported, same.

It will be seen that our freight and passenger business is altogether carried on by the railroad, and in our opinion it will be so until the Ohio is improved and the Beaver and Erie Canal is so widened and improved as to allow boats of from 250 to 400 tons passing back and forth.

This is the grand desideratum of the people in this community, who are suffering from the lack of proper facilities for doing business. If you think it advisable, and will send the blanks, we could flood the country from Beaver to Erie with petitions to the State or National legislatures on this question. We propose to be active in trying to secure this much-needed improvement. Our business is quite small the present year, compared with former years, and very much smaller than it will be when the Beaver and Erie Canal is enlarged.

Any reports that may come to you on the subject we will gladly receive.

We remain, Mr. Roberts, yours, very truly,

MCCASKEY & KERR.

THOMAS P. ROBERTS, Esq.,

U. S. Engineer's Office, Pittsburg, Pa.

P. S.—We ship annually perhaps 3,000 tons of fire-clay, fire-brick, and curbing and range work, by river.

No. 2.

EAST LIVERPOOL, OHIO, *December 27, 1868.*

I give as near as possible the amount of business from January 1, 1868, to the present time.

The arrivals and departures of steamers will average about four per day when the water is good. I have shipped 1,780 casks and crates of earthenware, at the average cost of about \$35 a package, and an aggregate of \$62,300. Were the Ohio River navigable for the entire year, the shipments of earthenware would reach 3,000 packages. The imports are groceries, dry goods, coal in great quantities, lumber, and salt. We have also a large and steady travel, all of which would be largely augmented by increased facilities of water communication.

Very truly,

ANDREW MILLER.

Mr. THOMAS P. ROBERTS.

No. 3.

STEUBENVILLE, OHIO, *January 1, 1868.*

Your favor in relation to amount of business here is at hand.

We have no steamers or barges built here; no correct data for the number of steamers landing here; however, all the freight and passenger boats generally land here. Our exports, such as nails, glassware, printing paper, cotton goods, woolen goods, coal, coke, &c., are 27,600 tons; cotton in bales, rags in bales, salt and dry goods, &c., are 15,000 tons. The railroad facilities being good, a preference is shown it.

Respectfully,

A. DOYLE.

No. 4.

PITTSBURG COAL WORKS, *February 24, 1869.*

* * * * *

We are now prepared to get out from 3,000 to 4,000 bushels coal daily, and our market is along the Ohio River, making it very important for the carrying out of our business that the navigation be improved. We experience much loss and trouble during protracted low stages of water.

L. ROCKERSHOUSEN & CO.

No. 5.

MATAMORAS, *Ohio*, 1868.

Barges built, 2; tonnage, 400. Steamboats arrived and departed during the year, 745. Number of passengers, about 1,500. Tons of freight received and exported, about 1,000, the greater part of which consists of tobacco, beans, and grain. Coal received, 30,000 bushels; salt received, 1,000 barrels.

Yours truly,

J. T. K. WARD.

No. 6.

HOCKINGPORT, OHIO, *December 21*, 1868.

* * * Occasionally small barges, say 16 by 100 feet, are built here. The arrivals of steamboats will average four per day. This point is quite a center for the surrounding country, and a very good trade is established. With better water facilities much greater results would doubtless be obtained.

Yours truly,

E. H. WILLIAMS.

No. 7.

CONCORD, KENTUCKY, *January 19*, 1869.

* * * Circular received December 11, 1868. * * * Referred to town trustees for answer. * * * Number of steamboats built, 4, the last one in 1867. Number of barges built last year, 2, averaging 200 tons. Capacity of our shops, saw-mills, &c., is equal to six barges per month, averaging from 200 to 300 tons.

The number of steamboat arrivals is three per day; tow-boats, one; transient boats not included, nor are the up-river packets that land as business requires.

The number of passengers will average ten per day each way. The quantity of freight per year, 500 tons. Exports, 500 cattle, 1,000 hogs, 1,000 sheep, 200 calves, 100 barrels eggs, 1,500 pounds butter, 100 dozen chickens, 10 barrels apple brandy, 5 barrels peach brandy, 10,000 bushels corn, 500 tons of hay, 1,000 cords of wood, 275 barrels apples, 1,500 barrels fruit, 800 flour barrels, 500 hogsheds, 300 pork barrels, 800 barrels flour, 100 wagons, 500 plows, 1,000,000 feet of lumber, including laths, and 700,000 shingles. We receive about three barges of coal per year, and 500 barrels salt.

* * * * * The Ohio River is our only facility for trade, and we are wholly dependent on it for all communication.

We are now building macadamized turnpikes to the interior, and our commercial and local improvements will double this year. Our country, a few miles back, affords an abundance of ship timber, which will ultimately make this town one of the most important ship-yards on the Ohio River.

Respectfully, &c.,

JOHN SPARKS,
Chairman Board of Trustees.

No. 8.

MAYSVILLE, *January 11*, 1869.

* * * Below I give the trade as correct as is possible:

Steamboats built, none; barges built, 3; wharf-boat built, 1. Steamboat arrivals and departures, from 1,000 to 1,200 per year. Number of passengers, 10,000. Tons of freight shipped, 9,000, consisting of grain, tobacco, hemp, pork, cattle, sheep, lumber, potatoes, &c. Imports: Groceries, dry goods, cotton, iron, nails, lumber, stores, fruit, &c. Coal received, 2,000,000 bushels; salt, 9,000 barrels; iron, 500 tons; lumber, 10,000,000 feet.

Your truly,

J. M. LOVE.

No. 9.

DOVER, KENTUCKY, *January 26, 1869.*

* * * The average number of steamboat arrivals and departures is 3 per day. Number of passengers each way, 6 per day.

		Value.
Hogsheads tobacco	1,200	\$180,000 00
Grain, bushels	20,000	24,000 00
Coal received, bushels	50,000	5,000 00
Lumber, feet	200,000	6,000 00
Salt, barrels	1,000	2,500 00

There is a great deal of other exporting and importing, which would be very difficult to arrive at. * * * Hope this will be satisfactory; if not, any other information we can give you on this point will be cheerfully given.

We remain, &c.,

JAMES McMILLAN,
Per W. H. H. RINGS.

No. 10.

FLORENCE, SWITZERLAND COUNTY, INDIANA,

December 21, 1868.

* * * In answer to your circular, would say that four steamboats land here daily; one plies between Cincinnati and this place, making a round trip every day; cannot estimate closely the number of passengers. There have been shipped from here during the past year:

2,000 tons baled hay, 200 tons baled straw, 1,000 barrels of flour, 500 barrels of whisky, 500 head of hogs, 200 head of cattle, 500 head of sheep, 10,000 barrels of potatoes, 2,000 barrels of onions, 200 barrels onion sets, 500 bushels of corn, besides some wheat, rye, barley, chickens, butter, eggs, cooperage, &c. Received, 200 barrels of salt, 30,000 bushels of coal, and \$80,000 worth of dry goods, groceries, lumber, &c.

"WHARF BOAT."

No. 11.

AURORA, INDIANA, *January 9, 1869.*

* * * In answer to your circular I would respectfully submit the following: Daily arrival and departure of steamers, average 10. Passengers, daily, 10. Yearly imports, iron, 400 tons; coal, 4,000 tons; lumber, 300,000 feet; salt, 1,000 barrels. Yearly exports, cooperage, 200,000 packages; hay, 5,000 tons; whisky, 20,000 barrels. Miscellaneous, to value of \$100,000.

Trusting, &c., I remain,

C. H. SPARKS.

No. 12.

WEST POINT, OLDHAM COUNTY, KENTUCKY,

December 31, 1868.

* * * * In reply, I will say in former years there has been two steamboats built here, one of 500 tons burden, and one of 100 tons; about three thousand steamboat arrivals and departures during the year, and will average about one passenger for each arrival and departure; value of merchandise received will approximate \$100,000. We export about 1,000 hogsheads of tobacco, 50,000 bushels of corn, 35,000 bushels of wheat, 6,000 tons of hay, and a considerable number of stock, such as mules, cattle, hogs, sheep, and milch cows and calves. We received about 10,000 bushels of coal, 1,000 barrels of salt, also considerable quantities of iron and nails, lumber, &c. The early completion of the new locks of the Louisville and Portland Canal will be of immense advantage to this place as well as others situated on the banks of the Ohio River and its tributaries.

Yours, &c.,

THOMAS W. JENNINGS.

P. S.—We have built in the last three years fifty barges and flat-boats.

T. W. J.

No. 13.

JEFFERSONVILLE, INDIANA, *December 31, 1863.*

I find on investigation that the exports from this city amount to over \$1,000,000 per year, and may be classed as follows:

From the Ohio Falls Car and Locomotive Works.....	\$500,000
From the Indiana State Prison, South, farming implements.....	300,000
Cement mills.....	100,000
Pork packed here.....	100,000
	<hr/>
	1,000,000

The above articles are all manufactured here, and are shipped to all points, both up and down the river.

Hoping, &c.,

D. M. DRYDEN.

Exhibit of the trade of Jeffersonville.

Articles.	Quantities.	Prices.	Aggregate value.
1865.			
Hulls built.....number..	5	Aggregate tonnage, 2,315.	\$61,884 64
Shingles.....do.....	291,000	\$6 per M.....	1,746 00
Oak and pine.....feet..	1,805,068	\$20 per M.....	36,101 36
Wrought iron.....tons..	30,000	\$100 per ton.....	3,000,000 00
Fire-brick.....number..	30,000	\$20 per M.....	600 00
Fire-clay.....tons.....	10	\$10 per ton.....	100 00
Salt.....barrels.....	30,000	\$3 50 per barrel.....	105,000 00
Steamers landing.....number..	850	Amount of revenue to city.	7,360 00
Flat and produce boats.....do....	365	do.....	1,825 00
1866.			
Hulls built.....number..	8	Aggregate tonnage, 1,796.	96,915 00
Shingles.....do.....	309,250	\$6 per M.....	1,855 00
Oak, pine, and poplar.....feet..	953,593	\$20 per M.....	19,111 86
Fire-brick.....number..	50,000	\$20 per M.....	1,000 00
Fire-clay.....tons.....	20	\$10 per ton.....	200 00
Salt.....barrels.....	40,000	\$3 per barrel.....	120,000 00
Steamboats landing.....number..	896	Amount of revenue to city.	7,400 00
Flat and produce boats.....do....	750	do.....	3,650 00
1867.			
Steamboat hulls built.....number..	10	Aggregate tonnage, 5,598.	140,532 00
Shingles.....do.....	545,000	\$6 per M.....	3,270 00
Oak and pine lumber.....feet..	609,094	\$20 per M.....	12,181 88
Wrought iron.....tons..	7,602	\$125 per ton.....	950,250 00
Pig metal.....tons.....	200	\$50 per ton.....	10,000 00
Coal.....bushels.....	309,005	13 cents per bushel.....	40,170 65
Salt.....barrels.....	31,000	\$3 per barrel.....	93,000 00
Fire-brick.....number..	30,000	\$20 per M.....	60,000 00
Steamboats landing.....do....	810	Amount of revenue to city.	3,280 00
Flat and produce boats.....do....	630	do.....	3,150 00
1868.			
Steamboat hulls built.....number..	8	Aggregate tonnage, 3,132.	86,100 00
Shingles.....do.....	390,000	\$6 per M.....	2,340 00
Oak, pine, and poplar timber.....feet..	197,102	\$20 per M.....	3,942 04
Cedar posts.....number..	1,250	25 cents per post.....	312 50
Assorted metal.....tons..	521	\$400 per ton.....	208,400 00
Pig metal.....do.....	250	\$50 per ton.....	12,500 00
Spike and hook iron.....do....	150	\$20 per ton.....	31,600 00
Coal.....bushels.....	455,000	13 cents per bushel.....	59,150 00
Salt.....barrels.....	7,000	\$3 per barrel.....	21,000 00
Fire-brick.....number..	65,000	\$20 per M.....	1,300 00
Fire-clay.....tons.....	20	\$10 per ton.....	200 00
Steamboats landing.....number..	850	Amount of revenue to city.	3,600 00
Flat and produce boats.....do....	750	do.....	3,550 00

The above is respectfully submitted for your consideration.

Respectfully, yours,

D. M. DRYDEN.

No. 15.

TELL CITY, INDIANA, *December 27, 1868.*

* * * We have from 1,800 to 2,000 steamboat arrivals and departures during a year, with several thousand passengers coming and going.

Freight shipped and received, about 12,000 tons, value \$1,000,000, consisting of furniture, chairs, castings, wagons, plows, plow-handles, beer, whisky, shingles, laths, lime, brick, barrels, casks, steamboat lumber, splits, woolen goods, leather, hides, sash, doors, flooring, barges, toys, belting, brushes, &c., and country produce are the principal freight shipped at this place.

Tell City is only ten years old, with 3,000 inhabitants, and has 34 engines and factories. * * * *

Respectfully,

F. STEINER.

No. 16.

ROCKPORT, INDIANA, *February 27, 1869.*

* * * * In response to your inquiries, I have to say that Rockport has a population of 3,000. We ship each year about 2,000 hogsheads of tobacco, 500,000 bushels of corn, 1,000,000 bushels of wheat, 50,000 bushels of potatoes, and other articles in proportion.

We build from five to ten barges and flat-boats per year. The arrivals and departures of steamboats at this wharf will average from two to three per day for the entire year. Coal mined and sold here, about 1,000,000 bushels per annum. Great fruit country.

Very respectfully,

JOHN R. DOUGHERTY,
Wharf-Master.

No. 17

EVANSVILLE, INDIANA, *December 28, 1868.*

Forwarding board trade report.

W. G. BROWN & CO.

Letter No. 14 (omitted) was from B. I. Caffrey, Louisville, an experienced lower-river pilot. He presented a valuable synopsis of the business of Louisville for 1868, but, as I have since obtained a later board of report, it is not found necessary to quote Captain Caffrey. He has also presented his views, as a pilot, on a proposed method of improvement, by means of wing-dams, for the troublesome Portland bar, just below the falls. The excellent and practical ideas he presents are, however, fully understood by General Weitzel, in charge of the falls improvement.

I herewith present a table exhibiting more particularly the leading exports of the principal cities, towns, and landings along the Ohio River from Pittsburg to Cairo. In making this table I was greatly assisted by Captain G. W. Rowley, United States consulting pilot, whose thirty-seven years' continued and active experience as a steamboat man upon its waters entitles his statements and opinions to more than ordinary consideration. The values of exports and imports he made up after careful computation and consideration, taking into view the country adjacent to the landings, and comparing places with each other when any of them were definitely known. We believe, however, that in a majority of instances we have underestimated the value of the river trade, more particularly at the smaller towns and country landings, but, as a whole, the table may be approximately correct.

The column of exports affords an interesting epitome of the character, manufacturing, and agricultural resources of the valley of the Ohio.

Beginning with the coal, iron, oil, lumber, and salt of Western Pennsylvania, we have the iron, stone, coal, grain, wine, and fruit of Southern Ohio, the tobacco and agricultural products of West Virginia, next the flour, hay, corn, wheat, and produce of Indiana and Illinois, with the hemp, tobacco, grain, and cotton of Kentucky and Tennessee. It is all suggestive of the wealth and fertility of soil in "a land flowing with milk and honey." There is everything in this valley which could make another England, with the lumber of Norway, the wines and fruits of France, Germany, and Italy, and the cotton of India; in short, the productions elsewhere of empires and continents.

The whole valley of the Ohio embraces 214,000 square miles, drained by numerous rivers, affording an aggregate of more than 4,000 miles of steamboat navigation. To such a domain, so large and truly national, it is not difficult to understand the impossibility of doing full justice in a cursory report.

Summary statement exhibiting the general character and estimated value of the river trade and commerce of the cities, towns, and principal landings along the Ohio River.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Pittsburg, Pa.....		Iron, coal, lumber, oil, and general manufactures.	Cotton, iron ore, grain, &c.	\$150,000,000	See App. A.
Saw-mill Run.....	1.5	Coal and salt.....	Lumber, &c.....	2,000,000	Coal, railroad, and iron mills.
Manchester.....	1.5	Steamboat hulls and salt.	Lumber, copper, and iron ore.	1,500,000	Ship-yards, &c.
Glass House, Pa....	2.2	Refined oil.....	Crude oil.....	100,000	Refineries.
Harbaugh Furnace.	3.0	.....	Iron ore and metal	200,000	Furnace & works.
Chartier's Creek...	3.4	Hulls and lumber.	Saw logs.....	10,000	Ship-yards, &c.
Ardesco Oil Works	3.9	Refined oil.....	Crude oil.....	150,000	Oil refinery.
Pork House.....	4.2	Iron.....	.....	50,000	Rolling-mill.
Middleton.....	11.5	Lumber.....	Saw logs.....	20,000	Steamboat and barge hulls.
Shousetown.....	15.0	.....	Lumber.....	25,000	Do.
Brick Works.....	16.7	Ornamental build- ing blocks.	.....	10,000	Brick works.
Little Sewickley...	17.0	Steamboat hulls, boats, &c.	Lumber.....	5,000	Ship-yards, &c.
Economy.....	18.0	Manufactures, fruit, &c.	.....	5,000	Independent colo- nists.
Baker's Landing...	23.3	Building and curb stone.	.....	5,000	Quarries.
Freedom.....	24.0	Refined oil, &c....	Crude oil and lum- ber.	60,000	Refineries and all kinds of hulls.
Rochester.....	25.5	Copper, iron ore, &c., iron imple- ments.	Logs, iron, &c....	3,400,000	Erie Canal trade, &c.
Phillipburgh.....	25.5	.....	.....	25,000	.....
Fire-Brick Works..	27.0	Fire-brick and building stone.	.....	20,000	Quarries and fire- brick works.
Montgomery's Isl'd	31.9	Building and curb stone.	.....	2,000	Quarries.
Industry.....	33.5	Steamboat hulls and boats.	Lumber.....	10,000	Ship-yards, &c.
Shipping Port.....	34.8	Coal.....	Groceries and dry goods.	25,000	Coal-mines.
Smith's Ferry.....	40.0	Crude oil and whisky.	do.....	500,000	Oil-wells.
Georgetown.....	40.0	.....	.....	6,000	.....
Liverpool, Ohio....	44.0	Earthenware.....	Coal, &c.....	150,000	Numerous earthen works.
Walker's Ldg., Ohio	46.0	Earthen pipe and ware.	do.....	100,000	Do.
Wellsville, Ohio...	47.9	Steamboat hulls and machinery.	Lumber, coal, &c..	100,000	Boat-yards and shops.
Brooklyn, Va.....	50.6	Hulls.....	Lumber.....	10,000	Saw-mills.
New Lexington, Va.	53.0	Baled hay and country produce.	Dry goods and gro- ceries.	15,000	.....
Port Homer, Ohio..	53.5	do.....	do.....	10,000	.....
New Cumberland, Va.	56.0	Fire-brick and clay ware.	Coal.....	250,000	Extensive fire-clay works.
Black Horse L'nd'g	58.0	do.....	do.....	100,000	.....
Freeman's Landing.	59.0	do.....	do.....	100,000	Do.
Cables Eddy, Ohio.	65.0	do.....	do.....	10,000	Mines.
Steubenville, Ohio.	67.5	General manufac- turing.	Lumber, coal, and general freight.	8,000,000	Manufacturing.
Coal Works, Ohio..	73.0	Coal.....	.....	50,000	Coal-mines.
Wellsburgh, Va....	73.8	Paper, glass, cot- ton, and woolen goods.	Dry goods and gro- ceries.	300,000	Coal-mines and manufacturing.
Bush Run, Ohio....	78.7	Country produce..	Dry goods, &c....	10,000	.....
Warren, Ohio.....	80.8	Grain, &c.....	Dry goods.....	15,000	.....
Short Creek, Va....	80.8	do.....	do.....	5,000	.....
Ohio River Coal Co.	83.0	Coal.....	.....	60,000	Extensive works.
Deep Run, Ohio....	84.0	Whisky.....	Grain.....	5,000	Large distillery.
Slacktown, Va.....	87.5	Coal.....	.....	10,000	Mines.
Martinsville, Ohio.	88.0	Iron manufactur- ing, &c.	Iron ore, pig metal, and coal.	200,000	General works.
Wheeling, W. Va...	90.0	Coal, iron, nails, glass, &c.	General freight...	30,000,000	See App. B.
Bridgeport, Ohio...	90.0	Coal and lumber..	Lumber.....	100,000	Mines & saw-mills.
West Wheeling, Ohio.	91.0	Paper, coal, barges, &c.	Lumber, produce, &c.	15,000	Mines, saw-mills, &c.
Richietown, Va....	91.5	Glass and iron....	Ore and pig metal	50,000	Large iron and glass-works.

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Benwood, Va	93.8	Iron and nails	Pig metal, &c.	\$150,000	Large iron-works.
Bellaire, Ohio	93.8	Produce and rail- road transfer.	Produce	175,000	
Belmont Coal Wrks	94.5	Coal .....	.....	160,000	Numerous and ex- tensive mines.
Wegee Coal Works, Ohio.	98.0	do	Groceries and dry goods.	50,000	Extensive mines.
Limestone Quarries, Ohio.	99.1	Limestone .....	.....	5,000	Quarries.
Moundsville, W. Va	101.0	Coal and produce ..	Groceries and dry goods.	50,000	Mines, Ohio side.
Mineral Hill Coal Works.	104.0	Coal	do	30,000	Mines.
Powhatan, Ohio ...	110.7	Flour and produce.	do	15,000	Flour-mills. Distillery.
Big Run, Ohio	110.8	Whisky	Grain	5,000	
Hornbrook's Land- ing, Va.	113.0	Produce	Dry goods and gro- ceries.	15,000	Distillery. Flour-mills, &c.
Whiskey Run, Va..	116.0	Whiskey	Grain	50,000	
Sunfish, Ohio	116.8	Tobacco, flour, and produce.	Grain, coal, dry goods, &c.	100,000	Saw-mills, &c.
Proctor's Run, Va ..	121.0	Lumber, staves, and produce.	do	20,000	
Bearsville, Ohio	125.5	Flour	Grain, dry g'ds, &c	20,000	Flour-mills. Saw-mills.
Martinsville, Ohio..	127.0	Ship building, lum- ber, &c.	Lumber, grain, dry goods, &c.	20,000	
Sardis, Ohio	130.4	Lumber, produce, and steamboat hulls.	Dry goods and gro- ceries.	10,000	Do.
Lodi and Narrows Run, Ohio.	131.6	Grindstones and cooper stuff.	.....	10,000	Quarries, &c.
Barnes's Run, Ohio.	132.4	Yellow pine and cooper stuff.	.....	10,000	
Whitten's Landing, Ohio.	134.7	Produce and coop'r stuff.	Dry goods and gro- ceries.	10,000	Do.
Sistersville, Va	136.0	Oil barrels, flour, and produce.	do	50,000	
Terrell's Landing, Ohio.	136.4	Tobacco and pro- duce.	Coal	10,000	Mills, &c.
Centerview, Ohio ...	139.0	do	do	15,000	
Matamoras, Ohio...	141.5	Flour, produce, to- bacco, cooper stuff, &c.	do	65,000	Do.
Grandview, Ohio ...	142.2	Oil barrels, flour, and produce.	do	20,000	
Landing, Va	142.6	Lumber	do	2,000	Saw-mills.
Johnson's Landing, Va.	144.5	Country produce..	Dry goods and gro- ceries.	5,000	
Union Land'g, Ohio.	145.2	Barrels, &c.	do	2,000	Cooperage.
Wells's Land'g, Va.	146.4	Country produce..	do	2,000	
Rea's Run, Ohio....	150.3	Produce and coop'r stuff.	do	10,000	Do.
Landing, Va	151.8	Country produce..	do	5,000	
St. Mary's Va	154.5	Cooper stuff and ship building.	do	30,000	Ship-yards and cooperage.
Newport, Ohio	155.5	Cooper stuff and produce.	do	5,000	
Newell's Run, Ohio	158.0	Cooper stuff, pro- duce, &c.	do	5,000	Oil-wells.
Landing, Ohio	159.5	Petroleum oil trans- fer.	.....	10,000	
Cow Creek, Va.	160.7	Country produce..	Dry goods and gro- ceries.	5,000	Do.
Barker's Landing, Ohio.	161.2	do	do	2,000	
Calf Creek, Va	161.8	do	do	2,000	Month Muskin- gum river.
Sheet's Land'g, Ohio	161.8	do	do	5,000	
Bull Creek, Va.	164.0	Crude oil, lumber, and cooper stuff.	.....	15,000	Do.
Little Muskingum, Va.	167.0	Lumber, &c. ....	.....	5,000	
Marietta, Ohio	171.0	Furniture, buckets, and iron.	Dry goods, coal, groceries, &c.	2,500,000	Iron-works.
Harmar, Ohio	171.5	Flour, tobacco, and grain.	.....	150,000	
Williamstown, Va..	171.0	Machinery, cast'gs, and produce.	.....	5,000	Grindstone mill.
Finch's Land'g, Ohio	172.5	Grindstones .....	.....	5,000	

General character and estimated value of the river trade &c.—Continued,

Place.	Miles from Pittsburgh.	Exports.	Imports.	Estimated value.	Remarks.
Cole's Landing, Va.	176.4	Produce, stone, &c.	.....	\$5,000	
Cutler's Landing,	178.0	Grindstones and produce.	.....	5,000	
Landing, Ohio.....	179.5	Building stone	.....	5,000	
Spencer's Landing, Va.	179.7	Country produce..	.....	5,000	
Parkersburg, Va...	183.5	Machin'y, oil, castings, and lumbr.	Dry goods, &c....	2,000,000	Oil-refineries.
Belpre, Ohio.....	183.5	Mills, flour, and produce.	.....	50,000	Mills and Little Kanawha river.
Hill's Land'g, Ohio.	189.8	Lumber, country produce, and stone.	Dry goods, &c....	3,000	
Walker's Landing, Va.	192.8	Country produce..	do.....	2,000	
Dake's Land'g, Ohio	193.0	do.....	do.....	2,000	
Curtis's Landing, Ohio.	193.5	do.....	do.....	2,000	
Kennedy's Land'g, Ohio.	195.8	Cooper stuff and produce.	do.....	2,000	Cooperage.
Hosking City, Ohio	197.4	do.....	do.....	50,000	
Harris's Landing, Va.	197.4	do.....	do.....	500	
Belleville, Va.....	199.5	do.....	do.....	20,000	Do.
Reed's Land'g, Ohio	199.5	do.....	do.....	5,000	
Pond Creek, Va.....	203.6	do.....	do.....	5,000	Do.
Jackson's Landing, Va.	205.5	do.....	do.....	5,000	
Robinson Tid Land-ing, Ohio.	207.7	Flour, produce, and cooperage.	do.....	5,000	Mills, &c.
Murraysville, Va..	207.7	Steam'b't hulls and produce.	do.....	20,000	Ship-yard.
Shade River, Ohio..	208.8	Yellow pine, &c....	Dry goods and groceries.	5,000	
De Witt's Run, Ohio	210.0	do.....	do.....	5,000	
Smith's Land'g, Va.	211.7	Grain and produce	do.....	4,000	
Portland, Ohio.....	214.0	Fruit and produce.	do.....	20,000	
Ravenswood, Va.....	218.6	do.....	Gen'l merchandise	20,000	
Hall's Land'g, Ohio.	221.5	Wood, bark, and produce.	do.....	5,000	
Hughes's Eddy, Va.	221.5	do.....	do.....	5,000	
Parr's Land'g, Ohio.	223.5	Grain and produce	do.....	5,000	
Ripley's Landing, Va.	228.5	Bark and produce.	do.....	25,000	
Landing, Va.....	230.5	do.....	do.....	5,000	
O K Land'g, Ohio..	230.5	Country produce..	do.....	5,000	
Letartsville, Ohio..	233.5	Grain and produce	do.....	5,000	
Landing, Va.....	233.5	Yellow pine lum-ber mills.	do.....	4,000	Saw-mills.
Antiquity Rock, O.	237.6	Coal, lumber, hulls, and produce.	do.....	50,000	Ship-y'ds and saw-mills.
Racine, Ohio.....	239.3	Hulls, produce, bark and lumbr.	General merchan-dise and logs.	25,000	Flour and saw-mills, &c.
Graham's Station, Va.	239.3	Grain and produce	Dry goods, &c....	5,000	
Syracuse, Ohio.....	243.4	Coal and salt.....	do.....	100,000	Salt-wells and mines.
Sliding Hill, Va....	243.7	Salt.....	do.....	50,000	Do.
Hartford City, Va..	244.6	Coal, salt, &c....	Gen'l merchandise	100,000	Mines, salt-wells, dry dock, coop'ge.
Landing, Va.....	245.8	Salt.....	do.....	10,000	Salt-wells.
Minersville, Ohio..	245.8	Coal.....	do.....	5,000	Coal-mines.
Pomeroy, Ohio.....	246.5	Salt, coal, iron, &c.	Dry lumber, &c....	8,000,000	Ship-yards, mines, iron-works, dry docks, &c.
Mason City, Va....	248.5	Salt, coal, and pro-duce.	Gen'l merchandise	50,000	Saw-mills, mining, &c.
Landing, Va.....	250.0	Bar-iron, salt, and coal.	do.....	50,000	Iron works, wells, and mines.
West Columbia, Va	251.5	Salt and coal.....	do.....	50,000	Saw-mills, wells, and mines.
Silver Run, Ohio...	253.4	do.....	do.....	25,000	Wells, mines, &c.
Cheshire, Ohio.....	255.4	Flour, hay, and produce.	do.....	25,000	Flour-mills, &c.
Mackere's Land'g, Va.	258.0	Country produce..	do.....	12,000	
Addison, Ohio.....	260.2	Hay and produce..	do.....	8,000	

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Point Pleasant, Va.	263.4	Coal, salt, lumber, flour, produce, &c.	Manufactures and merchandise	\$4,500,000	Trade of Big Kanawha river, (Appendix C.)
Gallipolis, Ohio	267.0	Merchandise and general manu- factures.	do		
Clipper Mills, Ohio.	271.0	Country produce.	do	4,000	
Raccoon Creek, Ohio	274.1	Pig metal, staves, &c.	do	60,000	Furnaces in interior.
Chambersburg, Ohio	277.5	Produce, mills, &c.	Logs and m'dise	8,000	Saw-mills, &c.
Managerie's Land- ing, Va.	278.3	Country produce, &c.	Gen'l merchandise.	10,000	
Bladensburg, Ohio.	279.0	Cooper stuff and tan bark.	do	5,000	
Hawley's, Va.	279.0	Country produce.	do	12,000	
Sample's, Ohio	279.6	Coal	do	20,000	Coal-mines.
Bushes' Mill, Ohio.	281.2	Flour and grain.	do	5,000	Flour-mill.
Glenwood Landing, Va.	283.7	Tan bark & cooper- age.	do	5,000	
Guthrie's Landing, Ohio.	284.4	Grain and produce.	do	7,000	
Jenkins's Landing, Va.	286.7	Grain, hay, and produce.	do	14,000	
Rankin's Landing, Ohio.	289.0	Tan bark, cooper- stuff, &c.	do	12,000	
Millersport, Ohio.	293.0	do	do	20,000	
Haskellville, Ohio.	295.0	do	do	15,000	
Nine-mile Run, Va.	297.0	Grain and produce.	do	5,000	
Gardner's Landing, Ohio.	298.7	Barrels and pro- duce.	do	20,000	
Guyandotte, Va.	302.7	Grain, flour, lum- ber, coal, &c.	do	100,000	Guyandotte River trade.
Indian Guyandotte Landing, Ohio.	304.0	Produce and grain.	do	20,000	
Maple Grove, Va.	306.3	Hay, produce, and grain.	do	10,000	
Symm's Creek, Ohio	306.3	Lumber and pro- duce.	do	12,000	Saw-mills.
Burlington, Ohio.	311.0	Grain, produce, and pottery.	do	25,000	Pottery, &c.
Ceredo, Va.	312.2	Produce and lum- ber.	do	10,000	Saw-mill & match factory.
Cattlettsburg, Ky.	314.5	Lumber, coal, &c.	do	500,000	Big Sandy River trade.
South Point, Ohio.	314.5	Grain and produce.	do	25,000	
Sheridan Coal W'ks, Ohio.	318.0	Coal	do	25,000	Mines.
Ashland, Ky.	320.0	Coal and produce	do	500,000	Lexington Rail- way.
Coal Grove, Ohio.	320.0	Fire-brick	do	25,000	Fire-brick works.
Bellefonte Landing, Ky.	321.5	Pig metal and fire- brick.	do	250,000	Furnace in inte- rior.
Amanda Furnace, Ky.	323.5	Pig metal.	do	100,000	Furnace.
Ironton, Ohio	325.0	Iron, nails, flour, &c.	General trade.	5,000,000	Severl iron-works.
Hanging Rock, Ohio	327.5	Iron, coal, and pro- duce.	Gen'l merchandise.	1,000,000	Furnace, &c.
Union Furnace Landing, Ohio.	329.5	Pig metal and pro- duce.	do	1,000,000	Do.
Oil Works, Ky.	330.3	Pig metal and re- fined oil.	do	150,000	Furnace and re- finery.
Greenupsburg, Ky.	333.7	Pig metal, coal, & produce.	do	1,500,000	
Haverhill, Ohio	334.0	Grain, flour, and produce.	do	20,000	
Smith's Run, Ky.	336.0	Cooper-stuff, &c.	do	5,000	
Junior Landing, Ohio.	337.0	Pig metal and pro- duce.	do	200,000	Furnace.
Reid's Landing, Ky.	338.0	Leather and pro- duce.	Hides and general merchandise.	50,000	Tannery.
Franklin Furnace, Ky.	338.0	Pig metal and pro- duce.	do	200,000	Furnace.
Excelsior Line Works, Ky.	342.5	Lime and produce.	do	100,000	Lime-kilns.
Pine Run Landing, Ohio.	344.2	Pig metal and pro- duce.	do	150,000	Furnace.

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Scioto Village, Ohio.	346.5	Fire-brick, lumber, metal, &c.	do	\$1,000,000	Brick-works, &c.
Springville, Ky.	353.0	Whisky, leather, &c.	do	200,000	Tannery and dis- tillery.
Portsmouth, Ohio ..	353.0	Iron, machinery, flour, &c.	General trade	12,000,000	Iron-works, &c.
Landing, Ohio	360.0	Tan bark and pro- duce.	Gen'l merchandise.	5,000	
Adams's Landing, Ohio.	362.0	Queensware, pro- duce, &c.	do	10,000	Queensware man- ufactory.
Quincy Landing, Ky.	364.0	Pig metal, bark, &c.	do	100,000	Furnace.
Boone Furnace Land- ing.	365.5	do	do	100,000	Do.
Landing, Ohio	369.0	Lumber and pro- duce.	do	5,000	Saw-mill.
Buena Vista, Ohio ..	371.0	Fruit, grain, and cut build'g stone.	do	100,000	Stone mill.
Rocksville, Ohio ...	372.0	Fruit, grain, and shale oil.	do	100,000	Oil-works & stone saw-mill.
Fairview Landing, Ky.	373.5	Stone and bark ...	do	50,000	
Vanceburg, Ky.	375.0	Flour, leather, bark, &c.	do	200,000	
Rome, Ohio	381.0	Grain, fruit, bark, &c.	do	50,000	
Stout's Landing, Ky.	383.0	Grain, fruit, hay, &c.	do	10,000	
Concord, Ky.	387.0	Flour, leather, lum- ber.	do	75,000	Saw-mill and flour mill.
Wrightsville, Ohio .	388.8	Grain, produce, &c.	do	15,000	
Manchester, Ohio ..	394.0	Flour, grain, lum- ber, &c.	General trade	230,000	Saw-mill and flour mill.
Springdale, Ky.	400.0	Grain, produce, &c.	Gen'l merchandise.	10,000	
Maysville, Ky.	405.5	Pork, tobacco, oil, &c.	General trade	8,000,000	Shale oil-works, &c.
Aberdeen, Ohio	405.5	Pork, tobacco, and produce.	Gen'l merchandise.	50,000	
Charlestown Land- ing, Ky.	410.5	do	do	20,000	
Logan's Cap, Ohio ..	410.5	Wine, tobacco, and produce.	do	8,000	Vineyards, &c.
Ripley Cap, Ohio ..	414.0	Grain, hay, tobac- co, whisky, lard, pork, &c.	do	5,000,000	Distillery, &c.
Dover, Ky.	416.5	Pork, lard, and to- bacco.	do	125,000	
Levanna, Ohio	416.5	Pork, lard, tobacco, and wine.	do	60,000	
Bushmeyer Landing, Ohio.	418.0	Wine	do	10,000	Vineyards.
Higginport, Ohio ...	421.3	Pork, grain, tobac- co, whisky, and wine.	do	2,000,000	Distillery, &c.
Augusta, Ky.	424.0	Grain and tobacco.	do	85,000	
Utopia, Ohio	426.5	Wine and fruit ...	do	10,000	
Rural Village, Ohio.	428.0	Tobacco, grain, wine, and fruit.	do	15,000	
Rock Spring Land- ing, Ky.	428.0	Whisky and tobac- co.	do	20,000	
Chilo, Ohio	431.0	Grain, wine, fruit, &c.	do	20,000	
Metcalf's Landing, Ky.	431.0	Tobacco	do	12,000	
Melville, Ohio	435.0	Whisky, flour, grain, &c.	do	250,000	Flour-mills.
Fosterville, Ky.	435.0	Tobacco and pro- duce.	do	100,000	
Stepstone, Ky.	437.5	Tobacco and coop- er-stuff.	do	15,000	
Moscow, Ohio	439.0	Flour, whisky, grain and fruit.	do	10,000	Distillery.
Landing, Ky.	439.0	Bark, wood, and cooper-stuff.	do	4,000	
Point Pleasant, Ohio	441.5	Country produce ..	do	2,000	
California, Ky.	444.0	Wood and produce.	do	10,000	
New Richmond, Ohio.	444.0	Whisky, grain, fruit, &c.	do	200,000	

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Palestine, Ohio	450.3	Brick, wood, flour, and fruit.	do	\$25, 000	Brick-works.
Buzzard's Roost, Ohio.	454.0	Wine, fruit, &c...	do	2, 000	Vineyard.
California, Ohio....	459.0	Castings	do	5, 000	Foundry.
Cincinnati, Ohio ...	466.5	Pork, gen'l manu- factures, &c.	General trade....	148, 500, 000	See Appendix D.
Refuse Works, Ohio	474.5	Hair, soap, can- dles, &c.	Dead animals' ref- use, &c.	50, 000	
Taylorsport, Ky....	478.0	Grain and produce.	Gen'lmerchandise	10, 000	
Lawrenceburg, Ind.	489.0	Flour, pork, grain, &c.	do	700, 000	Pork packing, mills, &c.
Petersburg, Ky....	491.0	Whisky, pork, &c.	Grain, &c.....	100, 000	Pork packing, dis- tillery.
Aurora, Ind.....	493.0	Tobacco, grain, flour, whisky, and pork.	Gen'lmerchandise	500, 000	Pork packing, dis- tillery.
Bellview, Ky.....	499.0	Grain and produce.	do	2, 000	
Rising Sun, Ind....	502.0	Pork, produce, live hogs and whis- kies.	do	500, 000	Pork packing, dis- tillery.
North's Landing, Ind.	505.5	Grain and hay....	do	5, 000	
Hamilton's Land- ing, Ky.	510.5	Hay, &c.....	do	5, 000	
Patriot, Ind.....	514.5	Whisky, pork, flour, &c.	do	125, 000	Distilleries, &c.
Sugar Creek, Ky....	518.3	Hay and produce.	do	10, 000	
Warsaw, Ky.....	523.5	Tobacco, flour and live stock.	do	80, 000	Flour-mills.
Florence, Ind.....	524.5	Hogs, hay and produce.	do	50, 000	Saw-mills, &c.
Log Lick Landing, Ind.	528.5	Hogs, hay and produce.	do	10, 000	Distilleries, mills, &c.
Vevay, Ind.....	533.0	Hay, hogs, and whisky.	do	300, 000	
Ghent, Ky.....	533.0	Tobacco and flour.	do	50, 000	
Craig's Bar, Ind....	537.2	Hay and grain....	do	6, 000	
Scott's Landing, Ky	538.0	do	do	2, 000	
Carrollton, Ky.....	541.0	Tobacco, grain, flour, pork, &c.	do	2, 500, 000	Kentucky River trade.
Brooksbyury, Ind...	545.0	Grain, produce, &c.	do	4, 000	Saw and flour- mills.
Madison, Ind.....	553.5	Starch, whisky, pork, flour, &c.	Lumber, coal, &c	12, 000, 000	Ship-yards, mills, &c.
Hanover Landing, Ind.	557.3	Grain and produce.	Gen'lmerchandise	2, 000	
Reed's Landing, Ind	561.2	Lumber and pro- duce.	do	10, 000	Saw-mills, &c.
Marble Hill, Ind....	566.3	Marble and stone.	do	10, 000	Marble quarries.
Garrett's Landing, Ky.	570.3	Tobacco and grain	do	10, 000	
Bethlehem, Ind....	570.0	Grain and hay....	do	2, 000	
Olden's Landing, Ky.	571.6	Tobacco and hay..	do	10, 000	
Westport, Ky.....	575.5	Tobacco, flour, whisky, &c.	do	25, 000	Distilleries, &c.
Herculeaneum, Ind.	580.5	Flour, hay and produce.	do	10, 000	Mills.
Charleston Land- ing, Ind.	586.5	Lime, grain, &c...	do	10, 000	Lime-kilns.
Utica, Ind.....	591.4	Lime	do	100, 000	Do.
Jeffersonville, Ind..	597.0	Pork, whisky, &c.	Coal, lumber, and general trade.	5, 000, 000	See Appendix E.
Louisville, Ky....	598.0	General trade....	Coal, lumber, and general trade.	15, 000, 000	Do.
Shippingport, Ky..	600.5	Cement	Stone	500, 000	
Clarksville, Ind....	600.5	do	do	100, 000	
Portland, Ky.....	602.0	General trade....	General trade....	4, 000, 000	General river transfer.
New Albany, Ind..	602.0	do	Coal, lumber, ore, &c.	15, 000, 000	Ship-building, &c.
Knob Creek, Ind....	612.0	Building stone....	Gen'lmerchandise	2, 000	Quarries.
Blunk's Landing, Ind.	615.0	Sand and building material.	do	5, 000	Sand pits.
Stewart's Landing, Ind.	616.3	Hay, grain, and produce.	do	5, 000	

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Strong's Landing, Ind.	621.0	Tobacco, grain, hay, &c.	do	\$5,000	
Applegate's Land- ing, Ind.	622.3	Tobacco, grain, hay, &c.	do	100,000	
West Point, Ky....	624.3	Tobacco, grain, hay, &c.	do	50,000	
Evan's Landing, Ind.	626.3	Hay and general produce.	do	5,000	
New Boston, Ind. ..	628.0	Hay, grain, and produce.	do	5,000	
Otter Creek, Ky. ...	631.0	Grain and produce.	do	5,000	
Rock Haven, Ky. ...	632.0	Tobacco, pork, flour, cotton, &c.	do	50,000	Cotton mills.
Tobacco Landing, Ind.	635.5	Tobacco, grain, hay, &c.	do	5,000	
Brandenburg, Ky. ..	640.0	Tobacco, grain, and produce.	do	50,000	Flour mills and pork packing.
Mauckport, Ind.	642.4	Hay, grain, and produce.	do	10,000	
Lopp's Landing, Ind.	646.0	Coopers' stuff and produce.	do	5,000	Cooperage.
Granny's Gut Run, Ky.	648.5	Lime, grain and produce.	do	10,000	Lime kilns.
New Amsterdam, Ind.	650.0	Grain and produce.	do	5,000	
Leavenworth, Ind. ..	658.0	Tobacco, grain, lumber, barrels.	do	50,000	Saw-mills, cooper- age, &c.
Fredonia, Ind.	661.0	Grain and produce.	do	4,000	
Amos Landing, Ind.	665.3	do	do	2,000	
Cedar Branch, Ky. .	666.1	Lime and country produce.	General merchan- dise.	3,000	
Hawkins's Land- ing, Ind.	668.0	Grain, lumber, and produce.	do	3,000	
Wolf's Creek, Ky. ..	671.0	do	do	10,000	Saw-mills.
Alton, Ind.	673.0	do	do	20,000	Do.
Galey's Landing, Ind.	675.5	Coopers' stuff and produce.	do	10,000	Cooperage.
Reno, Ind.	677.0	do	do	10,000	
Hatfield Landing, Ind.	679.0	Grain and produce	do	10,000	
Concordia, Ky.	680.7	Coopers' stuff, bark, and pro- duce.	Coal and general merchandise.	10,000	Do.
Derby, Ind.	686.5	Grain, produce, and bark.	General merchan- dise.	10,000	
Cedar Grove Land- ing, Ky.	687.5	Hay, grain, and produce.	do	3,000	
Cummings's Land- ing, Ind.	687.5	do	do	3,000	
Rome, Ind.	695.0	Flour, grain, hay, and produce.	do	10,000	Flour mills, &c.
Stevensport, Ky. ...	695.0	Tobacco, flour, grain, hay, and produce.	do	90,000	Do.
Holt's Landing, Ky.	697.0	Fruit, hay, and produce.	do	10,000	
Cloverport, Ky.	705.0	Tobacco, coal, hay, flour, &c.	do	150,000	Coal mines and mills.
Tobinsport, Ind.	705.0	Hay, grain, &c.	do	5,000	
Hog's Point, Ind.	708.5	do	do	10,000	
Deer Creek, Ind.	712.4	Grain and produce	do	10,000	
Rock Island, Ind.	713.0	Coal and stone.	do	1,000,000	
Hawesville, Ky.	717.0	Coal, tobacco, and general produce.	do	100,000	Coal mines.
Cannelton, Ind.	717.0	Coal, cotton man- ufactures, and produce.	do	500,000	Cotton mills and coal mining.
Tell City, Ind.	720.0	Flour and general produce.	do	150,000	Flour mills, &c.
Troy, Ind.	724.0	Flour, produce, and crockery.	do	150,000	
Emrick's Landing, Ky.	727.0	Grain and produce	do	10,000	
Woodland, Ind.	729.2	Coal.	do	10,000	Coal mines.
Lewisport, Ky.	731.0	Tobacco, grain, and produce.	do	25,000	
Grandview, Ind. ...	735.5	Tobacco, hay, grain, &c.	do	100,000	

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburgh.	Exports.	Imports.	Estimated value.	Remarks.
Honey Creek, Ind.	738.3	Coal and hay.....	do.....	\$30,000	Coal mines.
Rockport, Ind.	740.5	Flour, tobacco, grain, and produce.	do.....	150,000	Flour and saw-mills.
Landing, Ky.	742.0	Grain, hay, and produce.	do.....	15,000	
Snider's Landing, Ind.	744.5	Grain and produce	do.....	5,000	
Owenborough, Ky.	749.0	Tobacco, pork, grain, and produce.	do.....	1,000,000	Pork packing, mills, &c.
Bon Harbor, Ky. ...	752.0	Coal, tobacco, and grain.	do.....	10,000	
Enterprise Village, Ky.	753.5	Grain and produce	do.....	10,000	
Point Isabel, Ind. ..	758.0	Hulls, grain, and produce.	do.....	10,000	
Grissen's Landing, Ky.	758.0	Whisky, grain, &c.	do.....	10,000	Distillery.
Tobacco Warehouse, Ky.	767.5	Tobacco and grain	do.....	30,000	
Newburg, Ind.	769.8	Coal and general produce.	General trade.....	200,000	Saw and flour mills, &c.
Evansville, Ind.	783.0	Grain, pork, tobacco, and whisky.	do.....	12,500,000	See Appendix F.
Tobacco Bend, Ky.	785.5	Tobacco, grain, &c.	General merchandise.	50,000	
Dutch Bend, Ind. ...	788.0	Grain and produce	do.....	50,000	
Henderson, Ky.	794.5	Tobacco and produce.	do.....	3,000,000	Saw, flour mills, &c.
Maxwell's Landing, Ind.	796.0	Grain and produce	do.....	20,000	
Landing, Ind.	805.0	do.....	do.....	10,000	
West Franklin, Ind.	807.5	Grain, coopers' stuff, &c.	do.....	20,000	
Walnut Bend Landing, Ky.	814.0	Grain, tobacco, and produce.	do.....	50,000	
New York Landing, Ky.	815.7	do.....	do.....	50,000	
Mt. Vernon, Ind. ...	818.5	Pork, tobacco, grain, flour, &c.	General trade.....	500,000	Do.
Floyd's Landing, Ind.	823.5	Grain and produce	General merchandise.	10,000	
Uniontown, Ky.	832.5	Tobacco, coal, grain, flour, and whisky.	General trade.....	350,000	Coal mines, distilleries, mills, &c.
Wabash River.....	838.2	Grain, flour, and produce.	do.....	15,000,000	Included in Evansville, Shawneetown, Uniontown, &c. (See Appendix G.)
Raleigh, Ky.	843.3	Tobacco, grain, &c.	General merchandise.	20,000	
Shawneetown, Ill. ..	848.0	Flour, tobacco, grain, whisky, &c.	do.....	500,000	Saw and flour mill, &c.
Coal Works, Ill.	850.0	Coal	do.....	50,000	Coal railroad 3 miles to mine.
Carlew Coal Works, Ky.	857.5	do.....	do.....	5,000	Coal mines.
Sellers & Co's Works, Ky.	857.5	Coal and paper....	Cane, poles, and general merchandise.	5,000	Coal mines, paper factory.
Shotwell's Works, Ky.	859.3	Coal	General merchandise.	200,000	Coal railroad.
Cascyville, Ky.	860.5	Coal, tobacco, grain, hemp, &c.	do.....	150,000	Flouring mills.
Battery Rock, Ill. ...	860.5	Coal	do.....	50,000	
Weston, Ky.	864.2	Grain and produce.	do.....	20,000	
Ford's Ferry, Ky. ...	866.0	Tobacco, grain, hemp, &c.	do.....	75,000	
Cave-In-Rock, Ill. ..	869.0	Tobacco and country produce.	do.....	10,000	
Big Hurricane C'k, Ky.	873.7	Tobacco, hemp, grain, &c.	do.....	15,000	
Elizabethtown, Ill. ..	877.0	Grain, tobacco, pig metal, and lead.	do.....	250,000	Furnace, lead mines, &c.

General character and estimated value of the river trade, &c.—Continued.

Place.	Miles from Pittsburg.	Exports.	Imports.	Estimated value.	Remarks.
Rose Clair, Ill.....	879.5	Lead, grain, &c.....	do.....	\$50,000	Lead mines.
Carrsville, Ky.....	881.5	Tobacco, hemp, and grain.	do.....	20,000	
Trake's Coal Mines, Ky.	882.3	Coal.....	do.....	50,000	Coal mines.
Parkson's Landing, Ill.	884.2	Grain, tobacco, and produce.	do.....	10,000	
Buena Vista, Ill....	886.6	Grain, tobacco, and produce.	do.....	5,000	
Golconda, Ill.....	890.3	Tobacco, hemp, produce, and shingles.	General trade.....	100,000	Shingle factory, &c.
Bay City, Ill.....	899.0	Grain, produce, lumber, &c.	General merchan- dise.	10,000	Saw-mills, &c.
Mill Bayou, Ky....	900.0	Lumber, grain, &c.	do.....	10,000	Saw-mills, &c.
Birdsville, Ky.....	902.5	Tobacco, grain, hemp, &c.	do.....	10,000	
Smithland, Ky.....	907.5	Produce, tobacco, hemp, and lum- ber.	General trade.....	30,000,000	Saw-mills and lum- ber trade. (See Appendix II.)
Pull Tight, Ill.....	909.5	Produce, shingles, & coopers' stuff.	General merchan- dise.	30,000	Saw-mills, lumber trade, cooperage, &c.
Paducab, Ky.....	919.5	Hemp, pork, pro- duce, grain.	General trade.....	40,000,000	Tennessee river trade, ship-yards, &c.
Brooklyn, Ill.....	923.0	Grain, shingles, &c.	Gen'l merchandise	50,000	Shingle factory.
Metropolis, Ill....	929.2	Hulls, produce, to- bacco, hemp, &c.	General trade.....	200,000	Ship-yard, &c.
Fletcher's Landing, Ill.	937.0	Grain and produce.	General merchan- dise.	10,000	
Hilderman's Land- ing, Ill.	939.0	do.....	do.....	10,000	
Wilkinson's Land- ing, Ill.	942.5	do.....	do.....	5,000	
Eckle's Landing, Ill.	948.7	do.....	do.....	5,000	
Caledonia Landing, Ill.	951.0	Lumber, grain, hemp, tobacco.	do.....	10,000	Saw-mills, &c.
Landing, Ky.....	955.0	Tobacco, hemp, &c.	do.....	10,000	
Kelsey's Landing, Ill.	956.0	Grain and produce.	do.....	10,000	
Mound City, Ill....	959.0	Hulls, &c.....	General merchan- dise, lumber.	150,000	Naval station.
Cairo, Ill.....	967.0	Cotton, hemp, coal, salt, lumber, iron, grain, &c.	General trade.....	20,000,000	

Total annual value, Ohio River trade, \$634,007,000.

Respectfully submitted.

THOMAS P. ROBERTS,
Assistant United States Civil Engineer.

W. MILNOR ROBERTS,
U. S. Civil Engineer, in charge Ohio River Improvement.

APPENDIX A.

Pittsburg.

In regard to the commercial interests of Pittsburg nothing is very definitely known. It is almost exclusively a manufacturing city, and not much effort is made to promote unity of action among the different manufacturers, as is done in other cities through the boards of trade. The iron and steel interest, however, predominates, and the extent of the annual shipments can be more closely approximated. Next, perhaps, is the oil interest, which represents a capital in works and refineries about the city of \$9,000,000, invested in tanks, boats, and fixtures, \$6,000,000, or a total of \$15,000,000. There are sixty-one oil refineries in Pittsburg. Nearly half of the entire productions of the Pennsylvania oil-fields is refined here. Probably nearly one-half of the glass manufactured in the United States is made in Pittsburg, there being upward of fifty glass-works. It is believed by some good judges that the shipments by river westward amount to nearly as much in value as by railroad, and to the extensive producing manufacturers of Pittsburg should be added the immense business passing through by the Pennsylvania Central Railroad, estimated by some to equal in value \$350,000,000 annually. It is very difficult, however, to separate the river from the railroad shipments. The following items of Pittsburg manufactures were shipped by railroad alone, showing the character of the business for one year:

Plate, bar, sheet, and rod iron, 1864-'65, tons.....	143,097	Hardware, 1864-'65, packages.....	39,201
Nails, 1864-'65, kegs.....	152,645	Glass, 1864-'65, packages.....	214,710
Bolts and nuts, 1864-'65, kegs.....	15,766	Refined petroleum, 1864-'65, barrels.....	314,503
Castings, pounds.....	3,971,159	Crude petroleum, 1864-'65, barrels.....	169,221
Cannon, 1863-'64, pounds.....	32,606,000	Benzine, 1864-'65, barrels.....	29,441
Stoves, 1863-'64.....	14,863	Copper, 1864-'65, pounds.....	1,015,193
Machinery, pounds.....	1,527,696	Axes, 1864-'65.....	133,804
Steel, 1864-'65, pounds.....	10,696,586	Axles, 1864-'65, pounds.....	1,187,426
Steel wings, 1864-'65, pounds.....	672,970		
Steel springs, 1864-'65, pounds.....	790,939		

From the City Directory the following, but only partial, list of the principal Pittsburg manufactures is given. The Directory gives only the works which paid for a notice. This evidences the little interest all around taken in such things:

Acid works.....	3	Engine builders.....	36
Agricultural implements.....	6	File-works.....	5
Axes.....	2	Forges.....	2
Baled hay.....	1	Founders.....	16
Barrel manufactories.....	20	Furniture.....	31
Baskets.....	3	Flint glass.....	26
Belting, hose, and packing.....	4	Glass stainers.....	2
Blacksmiths—steamboat.....	6	Iron and nails.....	22
Blast furnaces.....	5	Iron bridges.....	6
Boiler makers.....	9	Iron founderies.....	2
Bolts and nuts.....	10	Iron railings.....	2
Bottle manufactories.....	10	Iron tubing.....	4
Brass founderies.....	11	Japaned ware.....	2
Breweries.....	39	Lightning rods.....	2
Brickmakers.....	7	Locomotive works.....	2
Bridge company.....	1	Lime glass.....	2
Broom makers.....	5	Oil-cloths.....	2
Brushes.....	4	Oil refineries.....	79
Carriage makers.....	7	Paint manufactories.....	2
Castings.....	4	Railroad iron.....	1
Chain manufactories.....	2	Rope manufactories.....	2
Coal dealers.....	57	Salt manufactories.....	2
Coach makers.....	3	Saw-mills.....	10
Coffin makers.....	3	Soap manufactories.....	4
Coke dealers.....	2	Steam pump manufactories.....	10
Carpet manufactories.....	4	Tanneries.....	10
Copper mills.....	3	Tobacco.....	17
Coopers.....	25	Tobacco dealers.....	172
Corks.....	2	Wagon makers.....	16
Cotton mills.....	5	White lead manufactories.....	8
Cracker bakeries.....	6	Wire manufactories.....	2
Distilleries.....	6	Window glass.....	21

It may be safe to estimate the commercial value of imports and exports of Pittsburg, including its manufactures, at not less than \$450,000,000 annually, one-third of which, or \$150,000,000, might be designated as the value of the river commerce.

From the files of the Pittsburg Commercial the following items of business for 1869 are taken:

	<i>Barrels.</i>
Crude oil receipts.....	1,026,920
Exports by rail, refined.....	596,475
Leaving for local consumption.....	430,445

Pig-iron blooms and river exports and ore receipts by Pennsylvania Railroad and canal for 1869 as follows:

	<i>Tons.</i>
Pittsburg, Fort Wayne, and Chicago Railroad.....	108,550
Cleveland and Pittsburg Railroad.....	28,510
Pennsylvania Railroad.....	56,260
Alleghany Valley Railroad.....	6,800
Pittsburg and Erie Canal.....	169,830

Coal shipments by river, 1869, 50,000,000 bushels, or 2,000,000 tons.

The business in lumber, &c., on the Alleghany and the trade eastward, by the Monongahela River, is not included in the summary statement in the table of exports and imports for Pittsburg, but the following statements of freight shipped by the Monongahela, taken from the annual report of Hon. J. R. Moorhead, president of the Monongahela Navigation Company, is interesting:

Table of freight shipped east and west on the Monongahela slackwater during the year 1869.

Articles.	Shipped eastward to Pittsburg.		Articles.	Shipped westward to Pittsburg.	
	Quantity.	Value.		Quantity.	Value.
Whisky..... barrels..	316	\$25,280 00	Coal..... bushels..	52,512,600	\$3,675,882 00
Boards..... feet..	3,162,483	126,499 32	Sand..... do.....	436,000	4,360 00
Timber..... feet..	1,573,298	1,101,308 60	Whisky..... barrels..	146,381	1,171,040 00
Pig iron..... tons..	2,088	6,264 00	Pig iron..... tons..	196	5,880 00
Iron ore.....	27,788	277,880 00	Wood..... cords..	1,518	6,072 00
Fire clay.....	3,644	18,220 00	Stone..... perches..	2,980	8,940 00
Pit posts..... number..	10,000	8,000 00	Posts..... number..	7,371	42,892 70
Sheep..... do.....	153	535 50	Brick..... do.....	4,298,270	22,743 00
Staves..... do.....	35,000	3,500 00	Sheep..... do.....	6,498	20,280 00
Classed freight..... lbs..	34,116,867	17,083,343 50	Oil..... barrels..	1,014	13,182 00
			Lumber..... feet..	310,538	12,421 52
			Classed freight.....	731,250	581,896 00
			Classed freight..... lbs..	19,170,376	9,595,188 00
Total.....		18,707,206 92	Total.....		15,160,777 22

Pittsburg packet lines.

Regular lines: daily line to Wheeling and Parkersburg, tri-weekly to Cincinnati, weekly packets to Portsmouth, tri-weekly to Wheeling, twice weekly to Zanesville, (Muskingum River,) besides numerous boats engaged in the freight business independently to Cincinnati, Louisville, Nashville, Tennessee River, St. Louis, Missouri River, Upper Mississippi, Illinois River and Minnesota, Memphis, Arkansas and White Rivers, Red River, and New Orleans. Besides these there are three daily packets leaving on the Monongahela and several independent boats engaged in freighting on the Alleghany River.

APPENDIX B.

WHEELING.

In the manufacture of iron and nails 2,295 persons are employed. The nail mills of Wheeling, viz, the River Side Iron Works, Belmont, La Belle, and Wheeling Iron and Nail Works, including two mills at Belmont and Bellaire, which are four miles distant from Wheeling, cut 17,350 kegs of nails per week, or about 902,200 kegs annually, at an average valuation of \$4,059,900. Besides, there are other rolling mills for the manufacture of railroad, bar, rod, hammer iron, sheet iron, bridge iron, bolts, &c. There are two spike mills, which turn out annually, for railroad and boat-building purposes, from 50,000 to 60,000 kegs annually. There are eight machine shops in the city, giving em-

ployment to 475 persons. There are besides eight foundries. There are six extensive glass manufactories, giving employment to 860 persons of both sexes; two large ship-yards, several carriage and wagon manufactories, woolen mill, several flouring mills, distilleries, &c. There are in Wheeling 36 manufactories of tobacco and cigars, returning an annual income license of \$150,000 to the national Treasury.

The above interesting statistics are extracted from a pamphlet published by order of the Wheeling city councils, on the "Vital manufacturing and other statistics of the city of Wheeling," by James E. Reeves, M. D.

Packet line of steamers.

The following lines of steamers ply between Wheeling and other points on the river: Daily to Steubenville, daily to Sunfish, daily to Matamoras, daily to Pittsburg, daily to Parkersburg, twice weekly to Cincinnati; occasionally boats up the Big Kanawha. The number of arrivals and departures of steamers may be safely estimated each at 2,100 per annum, or 6 daily.

APPENDIX C.

BIG KANAWHA RIVER TRADE.

Among the items of exports for 1869, passing Point Pleasant into the Ohio, from the Big Kanawha River trade was 1,873,525 bushels of salt, 2,763,000 bushels of coal. This river flows through a rich country, which as yet is only partially developed.

APPENDIX D.

Cincinnati packet lines.

Daily lines to Maysville, tri-weekly to Portsmouth, semi-weekly to Big Sandy River, weekly to Big Kanawha, semi-weekly to Marietta, weekly to Wheeling, semi-weekly to Pittsburg, twice daily to Louisville, twice daily to Madison, semi-monthly to Nashville, St. Louis, Memphis, and irregular packets to New Orleans; Tennessee River, Arkansas River, Kentucky River, with numerous transit packets to Pittsburg and other points. A number of the Pittsburg coal tow-boats make a trip every week to the city when there is water sufficient. No table in the last trade report is given, showing the number of arrivals and departures of steamers at Cincinnati. The whole number is known to amount to more than 3,000 yearly, or more than 230 monthly, 56 weekly, and eight daily arrivals, with a like number of departures.

As a manufacturing and commercial city Cincinnati has few equals. Situated about midway on the Ohio, between Pittsburg and Cairo, it naturally becomes the emporium of a great area of country embracing Central Kentucky, Southern Ohio, and South-eastern Indiana. The following table exhibits the manufacturing statistics of Cincinnati for 1869:

Class of manufactures.	No. of hands employed.	Value of products.	Increase per ct. since 1860.
Iron	9,412	\$17,068,628	222
Other metals	1,681	2,820,086	107
Wood	6,974	10,258,563	90
Leather	4,998	6,348,432	125
Food	1,907	16,053,632	113
Soap, candles, and oil	1,093	5,113,028	60
Clothing	11,617	10,807,715	60
Liquors	1,937	11,712,427	140
Cotton, wool, hemp, &c.	1,043	1,836,761	140
Drugs, chemicals, &c.	598	3,385,405	180
Stone and earth	2,312	2,643,318	200
Carriages, cars, &c.	742	1,156,216	50
Papers, &c.	396	701,164	50
Book-binding, &c.	468	674,080	400
Printing and publishing	2,822	4,279,714	180
Tobacco	4,096	4,040,214	550
Fine arts	577	884,183	340
Miscellaneous	2,402	5,494,596	68
Totals	55,275	104,657,612	123

It is found impossible to separate very accurately the river from the railroad imports and exports of the great cities. I have assumed about one-third of this business done at Cincinnati to be by the river. The table here presented, however, exhibits the total quantities of exports and imports by both river and railroad :

Articles.	Imports.		Exports.	
	1868.	1869.	1868.	1869.
Alcohol.....			\$2,352,191	\$502,228
Barley.....			232,701	168,115
Brooms.....		\$1,877,000	30,591	78,957
Butter.....	1,690,320	1,485,090	398,396	550,876
Boots and shoes.....	4,012,960	4,195,284	1,550,000	993,636
Candles.....	4,020	7,420	1,392,395	1,813,158
Castings.....			669,534	949,676
Corn.....	1,292,937	2,217,508	512,598	138,756
Cider.....	15,807	30,762		
Cheese.....	894,734	701,545	555,024	546,563
Cotton.....	10,848,640	14,841,036	10,650,000	14,860,644
Coal.....	2,520,000	3,000,000		
Coffee.....	7,175,666	7,563,776	4,970,416	4,412,445
Cooperage.....	326,157	360,525	155,038	251,425
Cordage.....	257,891	375,947	156,494	279,942
Cattle.....	7,007,845	7,871,310	3,907,350	903,875
Cement and plaster.....	175,827	171,523	46,614	44,437
Corn meal.....	20,113	21,218	29,820	18,729
Eggs.....	326,230	452,304	90,270	149,302
Flour.....	4,805,132	3,427,680	3,246,643	2,516,039
Feathers.....	229,530	233,220	126,390	178,980
Fish.....	736,837	569,471	74,816	101,775
Fruit, (green and dried).....	858,813	939,915	159,621	232,926
Furniture.....			4,389,480	6,294,190
Grease.....	300,196	348,725	45,656	36,530
Glass.....	160,964	113,133	38,080	21,652
Glassware.....	440,562	610,408	349,653	443,771
Hemp.....	2,443,095	5,074,909	1,133,000	1,019,960
Hides.....	869,614	817,411	664,089	540,321
Hardware.....	3,909,310	7,543,016	1,207,040	2,165,324
Hay.....	148,392	129,643	20,372	56,139
Hogs.....	8,007,918	9,951,160	752,403	1,429,820
Hops.....	69,648	69,124	14,276	14,278
Horses and mules.....	1,194,820	1,691,305	1,263,900	2,401,750
Iron and steel.....	7,670,076	6,359,807	3,571,902	3,699,123
Iron, pig.....	1,569,312	1,849,185	545,424	683,284
Iron, bloom.....	39,000	87,020		
Lard.....	1,705,544	1,764,640	4,960,544	4,274,652
Lumber.....	3,600,000	6,000,000		
Lime.....	203,883	185,487	25,852	23,761
Leather.....	733,110	878,364	872,550	986,352
Lead.....	682,038	456,372		
Liquors, distilled and rectified.....	13,289,550	12,122,104	7,745,610	12,963,460
Liquors, foreign and domestic.....	568,800	742,900	1,723,490	2,045,600
Liquors, malt.....	36,971	40,896	367,719	791,040
Liquors, wine.....	518,617	574,543	254,727	211,936
Merchandise.....	141,438,000	143,007,000	40,874,000	45,178,690
Molasses.....	1,400,960	2,694,862	655,640	1,319,184
Malt.....	711,072	572,047	841,046	787,064
Nails.....	1,908,672	1,663,290	1,227,480	1,323,840
Oakum.....	214,500	197,608		
Oats.....	629,289	675,540	51,127	141,900
Oils.....	838,560	654,570	6,204,660	6,583,775
Oil-cake.....	38,835	44,950	132,705	183,040
Provisions, beef, &c.....	68,100	30,434	388,738	378,716
Provisions, pork and bacon.....	2,994,589	2,752,768	11,169,764	12,301,033
Provisions, vegetables.....	597,343	397,264	220,705	231,759
Petroleum.....	1,216,356	1,365,480		
Pitch.....	8,205	7,300		
Queens and earthenware.....	362,320	249,760	415,940	121,000
Rye.....	345,846	482,090	118,812	278,614
Rosin.....	44,095	55,790		
Rice.....	278,040	266,955		
Spices.....	85,480	102,930	7,256	5,054
Sugar.....	7,764,572	8,086,132	3,803,840	4,133,910
Seed.....	1,066,233	683,378	475,917	446,209
Salt.....	749,458	594,136	359,903	383,556
Sheep.....	219,291	258,605	59,427	101,897
Ship-stuff.....	134,172	196,081	18,515	63,889
Starch.....	418,851	447,866	462,057	561,422
Stearine.....	118,615	106,596	222,355	315,020
Shot.....	66,822	67,896		
Soap.....			484,647	538,778
Tar.....	30,806	35,720		

Articles.	Imports.		Exports.	
	1868.	1869.	1868.	1869.
Tallow.....	\$731, 313	\$762, 696	\$34, 815	\$52, 520
Tea.....	424, 490	559, 700		
Tobacco.....	12, 819, 910	12, 117, 119	11, 927, 240	12, 015, 542
Turpentine.....	72, 774	102, 200		
Vinegar.....			76, 860	71, 454
Wheat.....	1, 803, 955	1, 699, 049	938, 566	1, 110, 142
White lead.....			195, 958	220, 500
Wool.....	470, 040	553, 080	498, 440	722, 784
Yarns.....	153, 941	173, 022		
Total.....	273, 237, 608	283, 865, 262	143, 288, 567	161, 581, 262

APPENDIX E.

LOUISVILLE, KENTUCKY.

The port list.—Arrivals and departures of steamers.

The aggregate of the arrivals and departures of steamers during the twelve months past, ending with the 31st of March, sums up as follows: This includes two daily packets to and from Cincinnati. One, and sometimes two, daily boats to Madison and Carrollton; two boats plying in the season to points on the Kentucky River; one regular Green River packet; two Tennessee River packets; two White River packets; four regular mail packets along to the Lower Ohio to Evansville and Henderson; twelve regular New Orleans packets for passengers and freight; two tow-boats or barge lines, and twenty-three coal tow-boats, which often average two trips per month to and from Pittsburg. In addition to these are occasional St. Louis, Memphis, and coast packets. As compared with the previous year, the port list indicates a marked increase in the river commerce; but in that year's estimate the coal boats were not fully enumerated.

Year 1867-'68.	Arriv- als.	Depart- ures.	Year 1868-'69.	Arriv- als.	Depart- ures.
April, 1867.....	285	280	April, 1868.....	264	260
May, 1867.....	254	249	May, 1868.....	277	279
June, 1867.....	225	225	June, 1868.....	207	209
July, 1867.....	167	167	July, 1868.....	187	186
Aug., 1867.....	163	167	Aug., 1868.....	197	187
Sept., 1867.....	150	165	Sept., 1868.....	217	224
Oct., 1867.....	161	164	Oct., 1868.....	233	237
Nov., 1867.....	161	164	Nov., 1868.....	236	228
Dec., 1867.....	199	198	Dec., 1868.....	214	206
Jan., 1868.....	180	174	Jan., 1869.....	237	246
Feb., 1868.....	154	151	Feb., 1869.....	241	237
Mar., 1868.....	246	237	Mar., 1869.....	284	279
Grand total.....	2, 345	2, 341	Grand total.....	2, 794	2, 778

Ship-building.

There are six ship-yards located here and in Jeffersonville, at the head of the falls, in addition to the very extensive ship-yards, foundries, &c., at the flourishing city of New Albany, at the foot of the falls, all of which, however, are embraced in this district by the Government steamboat law. The extent of this department of manufacturing can be estimated by the capacity of a single concern, which has been in operation since 1848, building an average of eleven boats per year. It consumed during 1869 700,000 feet of pine, 2,000,000 feet of oak lumber, 800 bales of oakum, 90 tons of iron and spikes.

Louisville is beautifully situated on a broad level plane or bottom, with room enough for indefinite enlargement. The vast water-power afforded by the falls of the Ohio destine it to be, at some time, a great manufacturing center. The impediment to navigation for many months in the year, caused by the falls, made Louisville necessarily a great shipping and transfer point. Now the trade is conveniently divided, there being a great city to receive manufactures and transfers nearly every product that passes.

The canal and river improvements at Louisville, now being done by the Government under General Weitzel, major of engineers, will shortly render it much less difficult

to transfer the through coal and other freight destined for the lower markets. The subjoined table exhibits the leading manufactories of Louisville. (NOTE.—The business of the cities of Jeffersonville and New Albany is not included.)

Name and character of factories and work.	No. of works.	Capital invested.	No. of opera- tors.	Aggregate of products.
Agricultural works.....	12	\$550,000	340	\$54,800,000
Architectural works.....	5	225,000	250	675,000
Ale and porter factories.....	6	65,000	65	260,000
Bolting factories.....	2	15,000	10	35,000
Breweries, &c.....	45	420,000	450	1,625,000
Bridge and iron company.....	1	175,000	300	425,000
Boat-builders.....	6	350,000	275	1,275,000
Brick-makers.....	32	220,000	600	825,000
Boiler-makers.....	3	80,000	50	225,000
Brush brooms.....	6	32,000	38	72,000
Bell foundries.....	3	60,000	40	165,000
Boots and shoes, &c.....	165	195,000	825	650,000
Cotton factories.....	3			
Candle factories.....	10	380,000	125	840,000
Candy manufacture.....	12	140,000	96	280,000
Car works.....	2	180,000	75	340,000
Chemical works.....	3	100,000	65	270,000
Carriage-makers.....	15	280,000	220	560,000
Cement factories.....	3	500,000	75	255,000
Cooper shops.....	24	150,000	118	300,000
Cordial manufacture.....	4	45,000	40	92,000
Cigar-makers.....	90	227,000	450	454,000
Clothing manufacture.....	15	450,000	650	900,000
Edge-tool makers.....	4	140,000	40	185,000
Foundries.....	40	1,500,000	1,650	3,425,000
Furniture manufacture.....	16	800,000	510	1,675,000
Flour mills.....	14	500,000	155	1,500,000
Gas works.....	2	975,000	180	425,000
Glue factories.....	3	14,000	25	36,000
Glass works.....	2	35,000	50	75,000
Gold pen manufacture.....	2	12,000	10	15,000
Hoop-skirt manufacture.....	2	5,000	10	10,000
Hair workers.....	3	10,500	12	15,500
Hat and cap manufacture.....	20	125,000	120	250,000
Iron architectural work.....	4	195,000	85	320,000
Lithographic work.....	3	25,000	60	40,000
Lead works.....	3	275,000	55	550,000
Lime mills.....	4	4,500	20	450,000
Mineral water.....	3	7,500	12	20,000
Machine shops.....	8	160,000	96	34,000
Oil mills.....	10	180,000	115	365,000
Organ manufacture.....	2	8,000	12	16,000
Pipe works.....	1	200,000	150	200,000
Paper mills.....	2	450,000	120	102,000
Paper collars.....	2	4,000	8	8,000
Pianoforte manufacture.....	3	95,000	45	190,000
Pump-makers.....	4	16,000	16	20,000
Potteries.....	3	10,000	18	20,000
Pepper, allspice, &c.....	4	27,000	20	80,000
Plane factories.....	5	35,000	35	105,000
Planing mills.....	8	180,000	180	275,000
Picture frames.....	6	20,000	30	40,500
Rolling mills.....	2	550,000	165	675,000
Rope bagging, &c.....	5	250,000	75	500,000
Sorghum works.....	1	30,000	6	10,000
Saddles, harness, &c.....	14	975,000	140	2,120,000
Scales, tucks, &c.....	3	15,000	20	35,000
Steam bakeries.....	2	45,000	30	135,000
Soap factories.....	12	210,000	100	670,000
Saw-mills.....	16	820,000	175	2,460,000
Stone and marble works.....	14	175,000	140	420,000
Surgical instruments.....	3	30,000	12	65,000
Steam-power companies.....	1	100,000		
Tanneries.....	16	625,000	212	1,375,000
Terra cotta works.....	2	25,000	24	60,000
Tobacco manufacture.....	27	675,000	750	2,715,000
Vinegar factories.....	5	28,000	25	95,000
Wagon-makers.....	14	125,000	65	25,000
Washing machines.....	4	25,000	16	65,000
Whisky and alcohol.....	8	790,000	175	3,010,000
Wood works.....	16	420,000	240	875,000
Woolen mills.....	4	325,000	125	820,000
Water works.....	1	750,000	130	
Grand total.....	817	17,835,500	11,626	42,979,000
Last year.....	669	16,313,000	11,681	40,091,745

* Just chartered.

Imports and exports of leading articles for the year ending March 31, 1869, and the value of the same.

Articles.	IMPORTS.		EXPORTS.	
	Quantity.	Value.	Quantity.	Value.
Alcohol.....barrels..	2, 226	\$211, 533	824	\$77, 703
Apples, green.....barrels..	31, 332	125, 328	5, 707	28, 535
Apples, &c., dried.....packages..	32, 960	131, 840	15, 195	68, 780
Ale and beer.....barrels..	88, 063	968, 693	16, 002	192, 024
Beans.....barrels..	3, 683	20, 464	977	8, 793
Bags.....bales..	10, 313	1, 134, 430	10, 902	1, 221, 024
Bagging.....pieces..	43, 693	873, 860	48, 141	1, 059, 320
Barley.....bushels..	87, 980	195, 060	18, 454	40, 598
Butter.....packages..	6, 863	310, 835	1, 160	58, 000
Bale rope.....coils..	10, 642	106, 420	18, 421	202, 919
Coal.....bushels..	21, 537, 250	2, 799, 842	14, 200, 000	2, 130, 000
Cattle.....head..	48, 122	4, 330, 980	18, 818	1, 787, 710
Cement.....barrels..	38, 485	80, 273	125, 678	171, 358
Cheese.....packages..	26, 644	133, 240	14, 042	84, 232
Cider.....barrels..	1, 271	13, 981	151	1, 502
Coffee.....sacks..	68, 835	2, 753, 400	47, 430	2, 134, 150
Cooperage.....packages..	79, 638	135, 871	89, 631	179, 362
Corn.....bushels..	643, 687	482, 764	214, 184	171, 347
Corn meal.....bushels..	30, 010	22, 507	27, 264	21, 811
Cotton.....bales..	136, 958	13, 695, 800	137, 592	14, 447, 160
Cotton yarn.....packages..	13, 128	118, 152	10, 038	100, 380
Crockery, &c.....packages..	6, 538	917, 120	5, 410	811, 500
Candles.....boxes..	16, 087	80, 435	40, 483	242, 898
Drugs.....packages..	59, 036	885, 400	46, 499	7, 207, 345
Eggs.....packages..	7, 474	119, 584	5, 166	87, 822
Express packages.....	37, 841	5, 676, 150	4, 152	539, 760
Furniture.....packages..	38, 342	3, 259, 070	117, 351	5, 887, 550
Flaxseed.....barrels..	10, 478	73, 346	1, 250	10, 000
Feathers.....sacks..	6, 553	196, 590	3, 731	115, 661
Fish.....packages..	169, 524	1, 017, 144	69, 094	408, 564
Flour.....barrels..	104, 047	837, 576	110, 636	885, 088
Fruit.....packages..	36, 868	184, 340	32, 537	162, 685
Glass.....packages..	46, 976	234, 880	27, 699	138, 495
Hay.....bales..	56, 512	169, 536	28, 982	101, 442
Hardware.....packages..	35, 547	3, 011, 495	37, 155	3, 058, 175
Hollow ware.....pieces..	22, 466	157, 262	85, 872	601, 104
Hoop poles.....	1, 460, 616	73, 030		
Hemp.....bales..	9, 721	388, 800	2, 259	141, 000
Hides.....barrels..	45, 166	451, 660	26, 288	262, 880
Hogs.....	219, 580	3, 732, 860	7, 900	135, 830
Horses and mules.....	50, 017	3, 362, 040	27, 872	3, 484, 000
Hops.....bales..	834	45, 870	360	19, 910
Implements.....	14, 172	283, 440	53, 180	1, 329, 500
Iron and steel.....pieces and bundles..	383, 326	1, 916, 630	208, 743	1, 043, 715
Iron, pigs.....tons..	23, 279	1, 163, 950	3, 175	158, 750
Lead and shot.....pigs and packages..	18, 829	208, 200	4, 796	57, 690
Leather.....rolls, &c..	8, 970	287, 040	14, 589	583, 560
Lard.....tierces..	3, 491	188, 514	17, 971	988, 405
Lard.....kegs..	5, 546	55, 460	13, 429	134, 290
Lumber.....feet..	26, 675, 585	933, 645	6, 321, 434	252, 857
Lime.....barrels..	18, 991	19, 940	23, 797	24, 986
Liquor.....casks, &c..	4, 258	1, 277, 400	4, 941	1, 472, 300
Malt.....bushels..	95, 823	239, 548	51, 127	132, 930
Merchandise.....packages..	451, 320	56, 415, 000	284, 541	36, 990, 330
Molasses and sirup.....barrels and pipes..	19, 940	896, 360	13, 350	627, 450
Nails.....kegs..	69, 850	419, 154	41, 821	271, 336
Oil.....barrels..	22, 647	1, 472, 055	16, 327	1, 093, 903
Oats.....bushels..	144, 977	101, 483	45, 492	40, 844
Oakum.....bales..	1, 487	80, 194	220	3, 940
Potatoes.....barrels..	45, 769	137, 307	55, 382	183, 837
Pork.....barrels..	5, 038	151, 140	43, 325	1, 299, 750
Pork and bacon.....barrels..	18, 794, 431	2, 631, 220	15, 541, 908	2, 331, 286
Pork and bacon, C. & T. (800).....barrels..	3, 398	417, 760	23, 258	2, 790, 960
Paper.....bundles..	135, 374	567, 570	36, 311	217, 866
Ptye.....bushels..	166, 104	240, 850	59, 865	84, 798
Rosin.....barrels..	2, 797	13, 985	423	2, 105
Rope.....coils..	1, 145	103, 050	313	28, 170
Rice.....tierces and barrels..	3, 654	181, 700	2, 067	103, 300
Sundries.....packages..	178, 558	17, 855, 800	178, 864	17, 886, 400
Spices.....packages..	6, 768	338, 400	4, 631	231, 550
Sugar.....hogsheds..	9, 734	1, 645, 312	4, 299	687, 840
Sugar.....boxes and barrels..	59, 423	2, 674, 035	40, 745	1, 833, 525
Sheep.....head..	163, 327	221, 476	11, 746	46, 984
Salt.....barrels..	521, 721	1, 460, 818	404, 310	1, 147, 584
Seeds.....packages..	20, 374	509, 350	19, 419	455, 575
Soap.....boxes..	17, 393	104, 358	19, 150	134, 113
Starch.....boxes..	18, 321	54, 963	9, 610	31, 232

Imports and exports of leading articles, &c.—Continued.

Articles.	IMPORTS.		EXPORTS.	
	Quantity.	Value.	Quantity.	Value.
Shingles..... M.	60,000	\$390,000	40,000	\$250,000
Tobacco.....hogsheads..	86,918	3,994,587	22,463	2,966,300
Tobacco.....boxes..	16,837	1,094,405	44,001	3,080,070
Tanni, &c.....bales..	889	42,672	2,639	126,627
Tea.....packages..	4,738	663,330	1,858	264,320
Tin boxes, &c.....	26,907	457,419	10,150	172,250
Tallow.....barrels..	4,954	173,390	3,252	113,120
Tar.....barrels, &c..	8,867	44,135	8,324	41,620
Turpentine and varnish.....	2,120	127,200	1,401	84,060
Vinegar.....barrels..	1,892	18,920	2,937	24,370
Whisky.....barrels..	48,958	4,651,010	58,933	5,598,635
Wheat.....bushels..	531,356	1,209,607	104,932	199,370
Wool.....sacks..	5,885	269,250	3,008	180,480
Wine.....casks and packages..	5,244	498,180	2,433	231,135
White lead.....packages..	11,544	46,176	18,276	73,104
Wooden ware.....packages..	48,629	194,516	20,690	118,760
Total valuation		170,535,250		136,957,690

EVANSVILLE, INDIANA.

Extracts from the annual report of the Board of Trade for 1867.

Evansville is situated on the Ohio River, below the chief obstructions to navigation during the season of low water, and the river from this point ont to the mouth is rarely closed by ice.

It occupies a position which should give it control of the commerce of four of the largest tributaries of the Ohio: Green River, which drains one of the richest regions of Kentucky, and which by slack-water improvement is navigable the entire year as high up as Bowling Green, two hundred miles, flows into the Ohio eight miles above Evansville; the Wabash, navigable for more than four hundred miles, flows into the Ohio fifty-five miles below Evansville; the Cumberland and Tennessee flow into the Ohio, respectively one hundred and twenty-five and one hundred and thirty-seven miles below Evansville; and with its frequent and regular packet lines this city has been able to control the greater part of the trade of those rivers. Situated about equidistant from the falls of the Ohio and the mouth of the river, (about two hundred miles each way,) with no near rival to compete, no large city to overshadow its growth, and with these important tributaries so greatly under its control, its location is extremely favorable for a large commercial city. The population of Evansville is estimated to be not less than 30,000, (1868.) In 1868 the real estate of the city assessed for taxation amounted to \$12,038,053; personal, \$4,025,324; total \$16,063,377, on which a tax amounting to \$217,563 58 was levied. The merchandise sales of Evansville, as fully set forth in the reports for 1867-'68, amounted to \$12,813,690 for 1867, and \$13,424,124 for 1868.

The value of articles manufactured was \$3,018,989 and \$3,429,421 for the two years respectively.

For the year ending November 1, 1867, the following table of the principal exports is given:

Articles.	Quantity.	Amount.	Estimated value.
Corn.....bushels..	1,199,707	\$0 80	\$1,599,765 60
Wheat.....bushels..	89,192	1 25	111,490 00
Oats.....bushels..	52,437	75	39,327 75
Barley.....bushels..	7,005	1 00	7,005 00
Pork.....barrels..	4,052	30 00	121,560 00
Flour.....barrels..	36,891	8 00	295,128 00
Meal.....barrels..	31,740	3 50	111,090 00
Whisky.....barrels..	4,061	85 00	345,185 90
Hay.....bales..	15,477	4 00	61,908 00
Tobacco.....hogsheads..	35,709	200 00	7,141,800 00
Cotton.....bales..	44,564	125 00	5,570,500 00
Salt.....barrels..	92,927	2 25	209,085 75
Total value of exports.....			15,613,845 10

Exports for the year ending December, 1868.

Articles.	Quantity.	Amount.	Estimated value.
Corn.....bushels..	2, 017, 794	\$0 80	\$1, 614, 227 00
Cotton.....bales..	38, 172	125 00	4, 771, 500 00
Flour.....barrels..	58, 840	8 00	467, 720 00
Hay.....bales..	12, 045	4 00	58, 180 00
Meal.....barrels..	16, 728	3 50	46, 548 00
Oats.....bushels..	54, 595	75	40, 946 25
Pork.....barrels..	12, 374	30 00	371, 220 00
Salt.....barrels..	90, 450	2 25	203, 512 50
Tobacco.....hogsheads..	19, 758	2 00	3, 951, 600 00
Wheat.....bushels..	1, 75, 410	1 25	219, 262 50
Whisky.....barrels..	6, 085	85 00	517, 225 00
Total value of exports.....			12, 261, 941 25

The exports by rail are included in the above tables, but much the larger business is done by river, and as the items (principally in cotton) exported by rail would be found in river *imports*, no further specifications would seem necessary. The reports do not exhibit very clearly the imports, nor do they appear to have gone very fully into the entire business of the city, thus sacrificing quantity somewhat for accuracy in the statement.

The following is a list of the steamboats registered and belonging to the port of Evansville for 1868:

Sam Groverdyke,	Crescent City,
Charmer,	Quickstep,
Zanesville,	Red Fox,
David Hamrod,	Mason,
Ada Lyon,	Fannie Brandie,
Romeo,	Petrolia, No. 2,
Cobb Webb,	Comet,
Charles Scott,	James Gray,
Sallie V.,	W'm Mumsyong
Ollie Sullivan,	Lincoln,
Mollie Norton,	Transient,
Armada,	Advance, No. 2,
Louisa,	Hoosier,
A. L., No. 1,	Sam. Orr.
Mate,	Total, 29.

Monthly statement of steamboat arrivals for 1868.

NOTE.—The arrivals only include one landing of packets per week, so that the actual arrivals are not fully shown in the table.

Months.	Arrivals.	Passed without stopping.
January.....	229	22
February.....	186	8
March.....	222	17
April.....	267	23
May.....	280	26
June.....	255	32
July.....	217	17
August.....	162	27
September.....	220	26
October.....	168	36
November.....	198	39
December.....	176	41
Total number for 1868.....	2, 586	314

Table of Evansville packet lines and distances.

	Miles.
To Cairo, on the Ohio River, daily.....	184
To Louisville, on the Ohio River, daily.....	185
To Carrollton, on the Ohio River, tri-weekly.....	66
To Cincinnati, on the Ohio River, weekly.....	317
To Bowling Green, Kentucky, daily.....	200
To Nashville, on the Cumberland River, semi-weekly.....	235
To Eastport, Mississippi, on the Tennessee River, semi-weekly.....	420
To Memphis, Tennessee, on the Mississippi River, semi-weekly.....	450
To Attica, Indiana, on the Wabash River, semi-weekly.....	455

APPENDIX G.

WABASH RIVER TRADE.

The valley of the Wabash is one of the richest purely agricultural regions in the country. Its trade is in grain, tobacco, whisky, flour, poultry, eggs, cheese, and country produce generally. It is lined with thriving towns and villages for 400 miles. Among the prominent ones are Mt. Carmel, Graysville, Vincennes, Montezuma, Terre Haute, Logansport, and Delphi.

APPENDIX H.

Cumberland River trade.

The rich valley of the Cumberland River, navigable for 700 miles, is rich in iron and coal, and it exports largely besides these, cotton, tobacco, hemp, cedar and yellow-pine lumber, flour, grain, whisky, &c. Among the great iron landings are Pinkneysville, Dykers, Hopewell Furnace, &c., with Eddyville, Tennessee Iron Works, Mammoth, Canton, Linton, Limeport, Tobaccoport, Dover, Cumberland Iron Works, Cumberland City, Sailors' Rest, Palmyra, Clarksville, Betseystown, Harper River, Ashport, Nashville, Carthage, South Fork, Mill Spring, and Burksville.

APPENDIX I.

Tennessee River trade.

It is impossible to detail accurately the immense business done to and from the Ohio and Mississippi with the Tennessee River, affording itself 700 miles of steamboat navigation. We have attempted a summary of it, included in the business of Paducah.

The principal products of the Tennessee Valley are cotton, iron, tobacco, hemp, cedar, yellow-pine and ship-builders' lumber, grain, flour, whisky, and cooper stuff.

Among the principal towns and landings engaged in this business are Paris, Johnsonville, Eastport, Tusculum; and, above Muscle Shoals, Bridgeport, Chattanooga, and Knoxville.

APPENDIX J.

TONNAGE OF VESSELS ON WESTERN RIVERS.

The following table, from the Pittsburg Chronicle, January 4, 1869, gives the enrolled tonnage of all the western rivers for the year ending June 30, 1868:

States.	No. of steam vessels.	Tonnage.	No. of barges.	Tonnage.	Total No. of vessels and barges.	Total tonnage.
Louisiana.....	930	52,025.28	33	3,303.43	263	55,328.67
Mississippi.....	15	2,396.33			15	2,396.33
Kentucky.....	75	22,818.05	14	4,554.82	89	27,372.83
Missouri.....	210	82,876.60	98	29,246.58	338	112,123.18
Iowa.....	28	3,258.87	28	1,743.42	56	5,002.29
Minnesota.....	53	9,774.41	87	9,207.60	145	18,982.01
Illinois.....	72	16,024.01	99	11,299.64	171	27,323.65
Indiana.....	26	5,293.88			26	5,293.88
Ohio.....	165	69,311.24	70	7,388.29	490	98,714.45
West Virginia.....	124	20,711.74	20	1,397.68	144	22,115.42
Pennsylvania.....	197	53,762.19	385	40,823.88	612	93,152.03
Tennessee.....	63	13,412.83			63	13,412.83

The figures in the above table are certainly in error in regard to the number of barges belonging to Pennsylvania. There were fully 2,000 barges engaged in the coal business alone, besides flats, &c., belonging to Pittsburg in 1869, ranging from 300 to 750 tons capacity each, representing a total of 800,000 tonnage.

During the year 1869 the number of steamers inspected at ports on the Ohio was as follows:

Place.	No. of steamers.	Tonnage.	Value.
Pittsburg.....	175	45,327.86	.....
Wheeling.....	68	10,383.05	.....
Cincinnati.....	105	34,182.39	.....
Louisville.....	82	32,245.00	\$2,107,950
Evansville.....	29	14,500.00	.....
	459	.....	.....

The Mississippi Valley.

As a matter of general interest, I herewith present some facts and statistics given in a memorial to Congress by the River Improvement Convention, held in St. Louis, February 12th and 13th, 1867.

No doubt the census for 1870, shortly to be taken, will show a vast increase in the products of the Mississippi Valley.

[Extract.]

"Your memorialists, appointed at the River Improvement Convention, held in St. Louis, February 13, 1867, would respectfully represent:

"That the States lying upon the banks of the Ohio and Mississippi rivers, fourteen in number, had, by the census of 1860, a population of 16,909,494, or more than half the whole population of the United States; and these two rivers have a coast line of 36,098 miles, while the coast of the Atlantic is 2,163 miles, and the Gulf of Mexico 1,764 miles, and of the Pacific 1,343 miles, on an outer line, of 21,354 miles, including bays and indentations. That these rivers drain an area of 1,785,267 square miles, more than half of the whole 3,001,002 square miles in the United States; and these fourteen States, in 1860, contained 94,402,869 of the 163,110,720 improved acres, and 126,703,393 of the 244,101,818 unimproved acres of the whole United States. And the valuation of property in these fourteen States shows \$8,467,511,574 of the whole valuation of the United States, \$16,078,358,715, showing very conclusively that these fourteen States pay more than half the taxes, work more than half the improved land, have the majority of the population, and also the majority of the land to develop of the whole United States. By the census of 1860, the whole product of the United States was valued at \$1,900,000,000, while the foreign exports of domestic produce were only \$373,189,274, or less than one-fifth of the whole product, leaving four-fifths for exchange in domestic commerce between the States. The proportion of the whole products afforded by these fourteen States we speak for, may be judged by these returns of their produce, gathered from the census of 1860, and compared with the whole United States, as follows:

	The fourteen States.	The whole United States.
Corn.....bushels..	632,454,375	838,792,740
Wheat.....bushels..	126,930,730	173,104,924
Oats.....bushels..	103,995,461	172,643,185
Tobacco.....pounds..	345,400,759	434,209,461
Sugar.....pounds..	222,636,000	230,982,000
Cotton.....pounds..	1,079,799,600	2,154,820,800
Wool.....pounds..	31,277,839	60,264,913
Hay.....tons..	9,297,743	19,083,896
Butter.....pounds..	239,601,405	459,681,372
Hemp.....tons..	69,470	74,493
Hogs.....	22,225,766	33,512,867
Bituminous coal.....bushels..	3,247,264,425	3,621,923,165
Horses and asses.....	4,804,634	7,400,322
Cattle.....	12,517,392	25,616,019
Sheep.....	11,973,315	22,471,275

"Showing for the river States a great preponderance in the products of the whole country."

"The tidal tonnage owned in the United States is returned in the census of 1860 as 5,353,868 tons, and the portion belonging to the fourteen States as 996,266 tons, but it is estimated by competent parties that the steamers on the Ohio and Mississippi have carried 7,905,216 tons during the year 1866; evincing the activity in domestic commerce of these river States, and this commerce but yet in its infancy, for it is developing daily and demonstrating that from these States has and must come the food supply for the whole nation and for exports, and that they must also supply the gold and silver States which are developing so largely and quickly upon the tributaries of their rivers."

I cannot close this report without quoting from the speech of Colonel James B. Eads, the eminent engineer, delivered at the St. Louis convention, the following description:

"This great valley lies between those parallels of latitude that are known to be most conducive to health and to the development of the mental and physical energies of man. In its capacity to produce the cereals, grasses, cotton, sugar, tobacco, hemp, vegetables and fruits of every kind; in the richness and variety of its mineral wealth, the grandeur and value of its forests, its inexhaustible quarries; in a word, in all the natural resources which conspire to increase the wealth and power of a people, the bounty of Providence has been most wonderfully manifested.

"The stream which in every direction penetrates this favored region, and is the grandest feature of North America, holds in its watery embrace the destinies of the American. Sooner or later it must give to the dwellers within this valley power and dominion over the whole boundless continent. It is the great arterial system of this republic, whose Heaven-wrought channels should teach the people who possess them that the Almighty designed them to dwell in love and harmony forever as one nation. There is not a drop within its noble veins that is not loyal to the Union. No effort can be made to sunder the Union that will not vibrate the alarm along its sensitive courses to their most distant and delicate extremities. Its vital branches and wonderful reticulations permeate and envelop the great body of our country, giving unity to amplitude, value to productiveness, and to the State resistless power, and an existence as enduring as human liberty and intelligence.

"Through its copious channels for all time to come are destined to circulate the sustenance and surplusage of its people. Life-giving commerce, which brings in her ever-welcome train peace and good-will to men, through its many convenient passages will distribute plenty and prosperity throughout the realm. The wealth and luxuries of the generous South will thread its devious currents to their very sources, and will be scattered within the sound of their trickling rills and sparkling cascades, while every wave that is borne toward the Gulf will be burdened with the reciprocated offerings of the colder latitudes. From its streams will be sent forth to the less favored nations of the earth the bountiful abundance of a land far more blessed than that which the prophet of old was permitted to gaze upon, but forbidden to enjoy.

"The influence and power of the people of this valley will be limited only by their virtue and intelligence. They can forever rivet to this Union with bonds firmer than brass or steel the States that lie beyond the mountains, outposts of the nation, and which, fringing the Commonwealth, constitute buttress and bastion, stockade or port-cullis, to give safety and repose to the mighty States within their borders. Self-protection, community of interest, ties of consanguinity, and national pride, will hold those States to the great central empire as immutably as the planets are held in their just positions by the attraction of the vast central orb, whose blessed influence gives them stability, and from whose exhaustless warmth they inherit vitality and nourishment."

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